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Lean readiness within emergency departments: A conceptual framework

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Abstract

Purpose – The purpose of this study was to develop a framework to assess the lean readiness within emergency departments (EDs) and identify the key quality practices deemed essential for lean system (LS) implementation.

Methodology – An extensive review of lean healthcare literature was conducted, including LS implementation within the healthcare sector (both generally and in EDs), best ED quality practices, essential factors for LS implementation within healthcare, and lean readiness assessment frameworks. The authors identified six main categories from a literature review (top management and leadership, human resources, patient relations, supplier relations, processes, and continuous improvement), and validated these based on experts' opinion.

Findings – Several factors were identified as crucial for EDs, including top management and leadership, human resources, patient relations, supplier relations, processes, and continuous improvement.

Practical Implications – This framework will help ED managers determine the factors that will enable/hinder the implementation of LSs within their premises.

Limitations – The framework has not yet been tested, which prevents the author from declaring it fit for EDs.

Originality – To the author's knowledge, this is the first lean readiness assessment framework for EDs and one of the few lean readiness assessment frameworks in the literature.

Keywords: lean system, healthcare, lean readiness, emergency department

1 Introduction

Healthcare providers around the globe are facing tremendous pressure to improve patient satisfaction and to serve more patients (Institute of Medicine, 2012; OECD, 2002; Porter and Lee, 2013). EDs specifically are facing huge challenges with regard to providing good-quality care and reducing waiting times for patients (Dickson *et al.*, 2009). The challenges are coming from the continuous demand and tight budgets, leading some hospitals to deliver poor performance, which has impacted patient satisfaction (Dickson *et al.*, 2009).

This has forced the healthcare industry to search for better ways to run their businesses in terms of providing better-quality and faster services. Therefore, improvement seems to be an inevitable goal for hospitals. Lately, the healthcare industry has shifted its efforts towards quality initiatives (QIs) such as lean systems (LSs), which were introduced by the manufacturing industries (Sloan *et al.*, 2014).

The main focus of LSs, regardless of the sector, is to improve the efficiency and effectiveness of the organisation by removing waste and non-value-adding aspects from every process. Sloan *et al.* (2014) note that despite the huge differences between manufacturing and healthcare or other service industries, the prerequisites for LSs are the same: top management and leadership commitment, employee involvement, customer and supplier relations, and shop-floor involvement and empowerment (Alnajem *et al.*, 2013; Sloan *et al.*, 2014). Sloan *et al.* (2014) explain that LSs can help hospitals to improve service delivery times, cost, quality, and productivity.

However, implementing LSs in healthcare environments might be tricky, involving special challenges. Timmons *et al.* (2014) attribute this to the presence of powerful and semi-autonomous professional groups. However, Sloan *et al.* (2014) believe that healthcare clinicians tend to accept the idea of LSs more openly, and that because of their work routine they are likely to experience most of the seven types of waste categorised by LSs (over-production, transportation, waiting, over-processing, motion, inventory, and defects). In the healthcare context, waste can include the unnecessary movement of patients and staff, missing equipment and supplies, delays, over-processing, medication errors, and the duplication of work. These can cause huge frustration for patients and staff alike. LSs provide hospital decision-makers with the chance to avoid and remove those frustrations.

Bucci *et al.* (2016) note that there have been few studies on lean within healthcare, particular regarding emergency departments (EDs). Similarly, Narayanamurthy *et al.* (2018) highlight the lack of lean studies within healthcare and emphasise that there is a need for a robust lean readiness assessment framework that suits healthcare to reduce the LS failure rate in the sector. Moreover, Sangwa and Sangwan (2018) explain that there are few lean assessment models and that most studies in the literature have used qualitative assessment models, which might not be helpful in other hospitals. Narayanamurthy *et al.* (2018) state that prior to their study, there was no lean readiness framework within healthcare. Although many researchers mention the importance of organisational readiness before implementing LSs (e.g. Radnor *et al.*, 2006; Al-Balushi et al., 2014), none have developed a framework to show how readiness can be assessed prior to lean implementation within EDs (Narayanamurthy *et al.*, 2018). This represents a clear gap in the literature.

This led the author to propose a conceptual framework that would enable EDs to assess their lean readiness prior to LS implementation. The author believes that hospitals can be significantly improved by implementing LSs, as shown in the reviewed literature (Al-Balushi *et al.,* 2014). Indeed, according to recent studies, LSs can help healthcare providers to cut waste and improve services, leading to a better patient experience and lower resource usage (Sloan *et al.*, 2014). However, in order to introduce LSs to ED staff, who might not have heard of LSs before, it would be wise to obtain an understanding of the current quality practices within their EDs. According to Alnajem *et al.* (2013), in order to reduce lean implementation failures organisations need to measure their readiness levels; this can be done by measuring the key quality practices deemed essential for the foundation of LSs. Thus, this study proposes a healthcare lean readiness assessment (HLRA) framework for EDs. The following research questions are formulated:

1. What are the prerequisites that EDs have to satisfy to be ready for lean implementation?
2. How can lean readiness within EDs be assessed?

2 Literature review

2.1 Lean in the healthcare context

Many hospitals around the globe are considering the implementation of LSs to improve their operations (Rees, 2011). According to Leslie *et al.* (2006), lean in the healthcare context is a strategy that aims to improve efficiency by focusing on value-adding activities that are important to patients. Doss and Orr (2007) argue that lean is applicable to every process within the healthcare industry, allowing hospitals to improve cycle times, reduce inventories, and

deliver better-quality services to patients. Similarly, Poksinska (2010) states that lean can encourage workers to improve their daily work and add value to every job they do. Dahlgaard *et al.* (2011) declare that hospitals can reap substantial benefits by implementing LSs, such as improved customer and stakeholder satisfaction and better services for patients. Leslie *et al.* (2006) argue that LSs can help organisations to reduce many types of waste by decreasing waiting times, removing unnecessary movement, having better flexibility, and promoting a quality culture within the organisation.

However, there is a misconception that LSs are expensive to implement; in fact, they are quite the opposite. Through LSs, healthcare providers can cut their spending by working more wisely and being more efficient and effective. According to Bahensky *et al.* (2005), LSs can help healthcare providers to make tremendous improvements without huge investment. Similarly, Decker and Stead (2008, p. 162) argue that hospitals do not have to have huge resources to implement LSs: 'One could argue that it is those hospitals with fewer resources that have the most compelling and urgent reasons to implement lean thinking by minimising waste of both human resources (time) as well as avoiding unnecessary waste of equipment, supplies, and testing.'

2.2 Lean within EDs

The reviewed literature presents different applications of LSs within EDs. Most of the cases presented showed significant improvement in terms of process flow and staff and patient experiences (Baumlin *et al.*, 2010; Banerjee *et al.*, 2008; Ieraci *et al.*, 2008). On the other hand, Dickson *et al.* (2009) showed that lean has failed to achieve the desired results when implemented in healthcare.

Furthermore, the reviewed literature shows different outcomes of LS implementation in EDs, such as better patient flow, reduced waste, and improved staff morale (Rees, 2011). According to Fillingham (2007), waste can be seen everywhere in healthcare, and healthcare can hugely benefit from LSs. Rees (2011, p. 57) remarks that this waste exists 'due in part to the range of professionals who when working to optimise patient care and processes make improvements to the existing configurations in an ad hoc manner. These uncoordinated additions result in the waste.'

Table 1 presents the benefits of LS implementation within the healthcare literature, focusing on EDs.

Insert table 1 here

However, in order to achieve the abovementioned benefits, hospitals need to understand how lean works, what types of waste they have, and what quality practices are needed to ensure a successful LS journey (Alnajem *et al.*, 2013). Womack and Jones (1996) explain that LSs revolve around five principles:

1. Specifying the value from the customer's point of view. In the healthcare context, Young and McClean (2008) define value from a patient pathway perspective, from the minute the patient enters the hospital pathway until they leave. Thus, there is a need to evaluate and redesign the pathway to create value for patients: each step the patient must go through needs to add value (Burgess and Radnor, 2013).
2. Mapping the value stream of each product and service, which will clarify exactly what does and does not add value and will challenge all of the wasted steps. Burgess and Radnor (2013) explain this step as splitting the patient pathway into value-adding

and non-value-adding activities. This mapping must be conducted by all staff who communicate with patients.

3. Improving flow by removing all obstacles that are hindering or delaying the movement of products or services. This can be done after specifying the value and mapping the value stream. Lean practices should be implemented to standardise processes around best practice; redesign of processes might be needed to eliminate non-value-adding activities, such as waiting for a bed, a specialist doctor, or medication (Burgess and Radnor, 2013).

4. Creating a pull system that responds to the downstream demands of patients. Removing all non-value-adding activities might not be possible at first; it might need to be done gradually, which will enable the hospital to pull the patient to the next process. Burgess and Radnor (2013, p. 222) declare the following regarding the healthcare context: 'theatre staff might telephone ward nurses to ask if there is a bed available for a patient while s/he is in the recovery bay following surgery; this action presents an attempt to push patients from one location to another. If there are no beds available in the ward or no one available to answer the phone then the recovery ward will soon become blocked consequently inhibiting theatre staff. Conversely, a "pull" process would involve ward staff releasing beds to patients in theatres based on their patient-demand knowledge.'

5. Seeking perfection, which represents a key pillar in LSs. This refers to engaging in continuous improvement, monitoring the situation, and making small and incremental improvements every day.

These principles need to be followed to achieve the ultimate objective of LS, which is improved efficiency and effectiveness, and that can be only done by eliminating the seven types of waste defined by the NHS Institute for Innovation and Improvement (NHSIII, 2007). These are explained in Table 2, alongside examples within healthcare.

Insert table 2 here

Radnor *et al.* (2012) explain different examples of waste reduction within hospitals around the UK after embracing LSs, such as:

- The average customer waiting time decreased from 23 days to 12 days (waiting waste).
- The time taken to process important categories of blood tests fell from two days to two hours (over-processing, waiting, and inventory waste).
- The average length of stay decreased from 6.29 days to 5.72 days (waiting and inventory waste).
- There was a 48% improvement in patient flow time (motion waste).
- Staff walking was reduced by 167 miles a year (motion waste).
- The death rate for patients fell by a third (defect waste).
- A change to the procedure for intravenous line insertion caused a 90% drop in the number of infections after just 90 days (over-processing and waiting waste).

The benefits for these hospitals were notable: one of them managed to increase its productivity by 20%, with fewer safety incidents but the same budget, infrastructure, staff, and technology, which demonstrates that LSs can improve current work by encouraging staff to work smarter, not harder (Radnor *et al.*, 2012).

2.3 The applicability of QIs and lean in EDs

Researchers and medical practitioners have identified several QIs and factors deemed important for enhancing the quality of service in EDs. According to El Sayed (2012), the main objective of EDs is to provide efficient and effective services to end customers (i.e. patients), and QIs such as continuous improvement (CI) and total quality management (TQM) can help EDs to ensure patient satisfaction. Despite the doubts regarding the applicability of QIs in healthcare raised by some researchers (e.g. Isern and Pung, 2007; Baumol, 1993), the healthcare industry has been implementing QIs for several years, which shows the applicability of these approaches. Initiatives noted in the literature include rapid cycle change (Powell *et al.*, 2009), six sigma (Pyzdek and Keller, 2009), business process re-engineering (Hammer and Champy, 1993), and LSs (Radnor *et al.*, 2012).

Other researchers (e.g. Holden, 2011; Timmons *et al.*, 2014) believe that LSs can help EDs to prosper and to enhance patient satisfaction. However, QIs require the involvement of the whole organisation and need to be measured and reviewed on an ongoing basis to ensure continual improvement (El Sayed, 2012). More importantly, organisations need to assess their readiness prior to implementation, as each QI requires a unique set of quality practices (Alnajem *et al.*, 2013; Narayanamurthy *et al.,* 2018). Laffel and Blumenthal (1989) note that there are several quality practices needed for EDs to ensure quality services, such as top management and leadership commitment to quality, the use of reliable indicators of quality, and the involvement of front-line workers in quality improvement efforts.

According to Timmons *et al.* (2014), LSs require all staff to be involved in the review of processes, the identification of waste, and the changes required to eliminate it, so the lean journey is not an easy ride by any means. It is not a 'plug-and-play' system, where the

organisation installs the system and reaps the benefits; rather, it is a philosophical approach that requires a certain culture (Radnor and Bucci, 2007; Hines *et al.* 2008).

Waring and Bishop (2010) explain that EDs are more receptive towards LSs compared with other hospital departments. Eller (2009) reviews 18 articles that demonstrate the implementation of LSs in 15 EDs in Canada, the United States, and Australia. His study reveals the numerous benefits gained by the EDs after LS implementation, such as improved patient care and decreases in the number of errors, waiting times, the length of stay, and the number of unseen patients. The study also explains the success factors to ensure successful LS implementation, such as employee involvement, management support, and readiness for change.

LSs can help in improving patient satisfaction by improving the patient flow, which will lead to less crowding or reduced waiting times for patients. Dickson *et al.* (2009) explain the benefits gained by EDs after implementing LSs: improved patient flow, decreased waiting times, and enhanced patient satisfaction. One form of lean waste is 'defect waste' or, in the healthcare context, 'medication errors'. Unorganised EDs might be overcrowded, which can cause doctors and nurses to make errors. Kulstad *et al.* (2010) found a strong correlation between ED crowding and medication errors. Thus, LSs can help EDs to have better working environments, thereby reducing staff stress. Table 3 shows several lean tools that have been successfully implemented within hospitals, which shows the applicability of LSs in the healthcare industry.

Insert table 3 here

2.4 Lean obstacles and barriers in healthcare

Thelen (2016) declares that the failure rates for lean adoption within the healthcare sector range between 50% and 95%. Lean consultants have attributed this to several factors, such as a

lack of knowledge about lean concepts, a lack of a proper system to solve employee issues, and a lack of training (Narayanamurthy *et al.* 2018). Bhasin (2012) declares that LSs require distinct organisational cultures and that despite the benefits they might bring to organisations, they will not work well if the organisational cultures are not supportive.

Narayanamurthy *et al.* (2018) identifies three factors that contribute to LS adoption failures: the absence of adaptation, a lack of readiness, and a lack of a systemic approach. According to Bortolotti *et al.* (2015), many organisations fail in LS adoption because their main focus is on technical issues (lean tools), ignoring human-related practices. Zhu and Lin (2017) believe that the failures come from a lack of top management support, while Sharma *et al.* (2015) relate the failures to a lack of training.

Rees (2011) discusses the difficulties in LS implementation within EDs and attributes them to the difficult environment resulting from the implicit tension between medical and administrative staff. He insists that LS introduction in EDs needs sensitivity and perseverance.

Notably, the main factor contributing to lean failures, regardless of sector, is the organisation failing to assess its lean readiness before pursuing lean implementation (Radnor *et al.*, 2006; Alnajem *et al.*, 2013; Al-Balushi *et al.*, 2014; Garza-Reyes *et al.*, 2015; Narayanamurthy *et al.*, 2018). According to Radnor *et al.* (2006, p. 4):

> Organisational readiness is a key factor in the success of Lean. This includes generating a vision of a fully integrated Lean organisation at the outset of implementation; being realistic about the timescales involved in making changes and embedding the process; engaging staff and helping them to understand how the Lean approach may impact upon

the organisation and; evaluating the degree to which a process and customer view already exist within the organisation.

2.5 Lean readiness assessment

Several researchers emphasise the importance of organisational readiness prior to LS implementation, and some declare that it is a prerequisite (Alnajem *et al.,* 2013; Garza-Reyes *et al.*, 2015; Narayanamurthy *et al.*, 2018), including in the healthcare industry (Radnor, 2011; Al-Balushi *et al.*, 2014).

Assessing lean readiness in service industries might not be easy compared to in manufacturing industries; service industries are intangible in nature, as they provide customers with intangible services, which are harder to measure. According to Radnor (2011) and Radnor *et al.* (2012), lean is more difficult to implement within service industries because most of the important metrics (e.g. processes, customer expectations, demand, and strategy) are harder to measure, as they are subjective and perceptual. Furthermore, Radnor and Bucci (2007) explain that service industries might face a tough task in implementing LSs, as the processes of identifying customer value and improving process flow might be unclear or complex. Narayanamurthy *et al.* (2018) declare that a lack of LS implementation within the healthcare context increases the chance of business failure in the sector.

A number of lean assessment frameworks have been presented in the literature in the past 10 years (Saleeshya *et al.*, 2013; Karim and Arif-Uz-Zaman, 2013; Alnajem *et al.,* 2013; Narayanamurthy *et al.*, 2018; Sangwa and Sangwan, 2018). Table 4 lists these frameworks and explains how the researchers developed them to assess organisational performance in relation to LSs. Some are similar, but each framework takes a different approach in terms of the categories

used or the ways of asking questions; this can be attributed to the fact that lean measurements depend on how the problem is identified by the researcher (Karim and Arif-Uz-Zaman, 2013).

Karim and Arif-Uz-Zaman (2013, p. 176) declare that 'most of the methods proposed were not supported by practical implementation and therefore validation could not be guaranteed'. Saurin *et al.* (2011) suggest that most lean assessment models do not assess the lean practices that take place on the shop floor (e.g. visual management, process flow, organisation of items, employee empowerment, etc.).

Insert table 4 here

2.6 Readiness factors for lean implementation within healthcare

In order to ensure the success of LSs within EDs, several critical success factors need to be identified. These include processes; signage and visual management; staff training; top management and leadership; problem-solving techniques; employee empowerment; and communication. These can all contribute to improving processes and patient satisfaction.

Kruskal *et al.* (2012) identify the following prerequisites to LS implementation: respect for all staff members; the elimination of waste; the standardisation of work processes; the improvement of flow in all processes; the use of visual signals to communicate and inform; and the use of specific tools to perform targeted data collection and analysis and to implement and guide change. LSs offer several practices to facilitate these tasks, such as value stream mapping (VSM) for visualising the current state of a process and identifying activities that add no value; root cause analysis for determining the root cause of a problem; team engagement and empowerment; and visual management (VM) (Kruskal *et al.,* 2012).

Bucci *et al.* (2016) conduct a study to examine lean implementation within EDs in different countries. They emphasise the importance of well-organised processes, problem-solving, employee involvement, and standardisation.

Furthermore, Radnor *et al.* (2006, p. 65–66) identify potential factors for organisational readiness towards LSs in their study in the Scottish public sector: acceptance of the need to change, the capacity for improvement, teamworking, a supportive culture, understanding customers, adopting a process-based view, and collecting improvement data.

3 Methodology

Prior to the development of the HLRA conceptual framework, a great deal of literature was reviewed to identify the key practices required for LS implementation within healthcare; in addition, ED best-quality practices, such as those cited by The Royal College of Emergency Medicine, were reviewed.

The research is exploratory in nature, thus the data obtained is secondary. First, the relevant literature was reviewed. The authors focused on the most recent literature (from 2013 to 2018). The review covers aspects such as lean assessment frameworks, lean critical success factors, and articles dealing with LSs within hospitals in general, and more precisely in EDs.

Several reputed data sources were searched, such as Taylor and Francis Science Direct, Google Scholar, Springer Link, and Emerald. Primary keywords used included ‘lean in healthcare’, ‘lean in ED’, ‘lean readiness assessment’, ‘lean critical success factors’, ‘lean enablers’, etc. Based on this search, articles were selected that met the criteria of practices in lean healthcare implementation and presented a model or framework.

After analysing the literature, the main categories were identified and the conceptual framework developed. As a second phase, in order increase trustworthiness regarding the findings of the main categories, and thereby enhance the robustness of the assessment framework, an expert panel was approached to validate the authors' findings and assumptions, and to ensure that the categories represented the main factors to enable the authors to measure the lean readiness level within EDs. A total of 65 experts in lean healthcare were contacted through their hospitals and via LinkedIn; the experts worked in hospitals in countries such as the Canada, Egypt, Germany, India, Poland, Spain, UK, and USA. A total of 28 experts agreed to validate the conceptual model; however, only 17 returned the forms to the authors on time. The experts were chosen based on the following criteria:

1. They had to work in a hospital ED.
2. They had to have dealt with a lean/quality initiative project in the ED.
3. They had to have at least five years of experience in healthcare.

The experts were asked to answer four key questions to validate the framework:

1. Do the categories represent essential factors to measure lean readiness within EDs?
2. Are the questionnaire items well written, and do they accurately present each category?
3. Based on your experience in lean implementation within EDs, is the relationship between the six categories well illustrated, and does this enable clear understanding of lean readiness assessment?
4. Are you confident that this framework will enable the EDs to obtain a good understanding of lean readiness within EDs?

The experts were also asked to provide their opinion on the framework, and to comment on or suggest the additional/removal of categories and questionnaire items. The experts were assured of anonymity.

The feedback from the experts was mostly positive. The experts validated the framework proposed by the authors, agreeing that the six main categories presented are essential for considering ED readiness towards lean implementation.

According to one expert, the proposed framework is suitable for providing a 'helicopter view' of ED, as it can provide basic information on not only the ED, but on the whole hospital, which will enable the ED to understand their readiness towards lean readiness. Another expert stated that the framework could be used as a first step to check whether the foundation is in place to implement an LS, since without appropriate foundations, no lean idea can be implemented successfully. Most of the experts expressed their agreement with the main categories and with the questionnaire items used, stating that they believe this framework to be very useful for any ED that wants to establish an LS. In addition, they concluded that the framework can help in identifying the lean readiness of any ED.

Several suggestions were offered by the experts related to the questionnaire items themselves; this resulted in changes to the wording of some questions, and the addition of new questions that the experts felt were key to understanding lean readiness within ED.

A flow chart depicting the research methodology used in this study is shown in Figure 1.

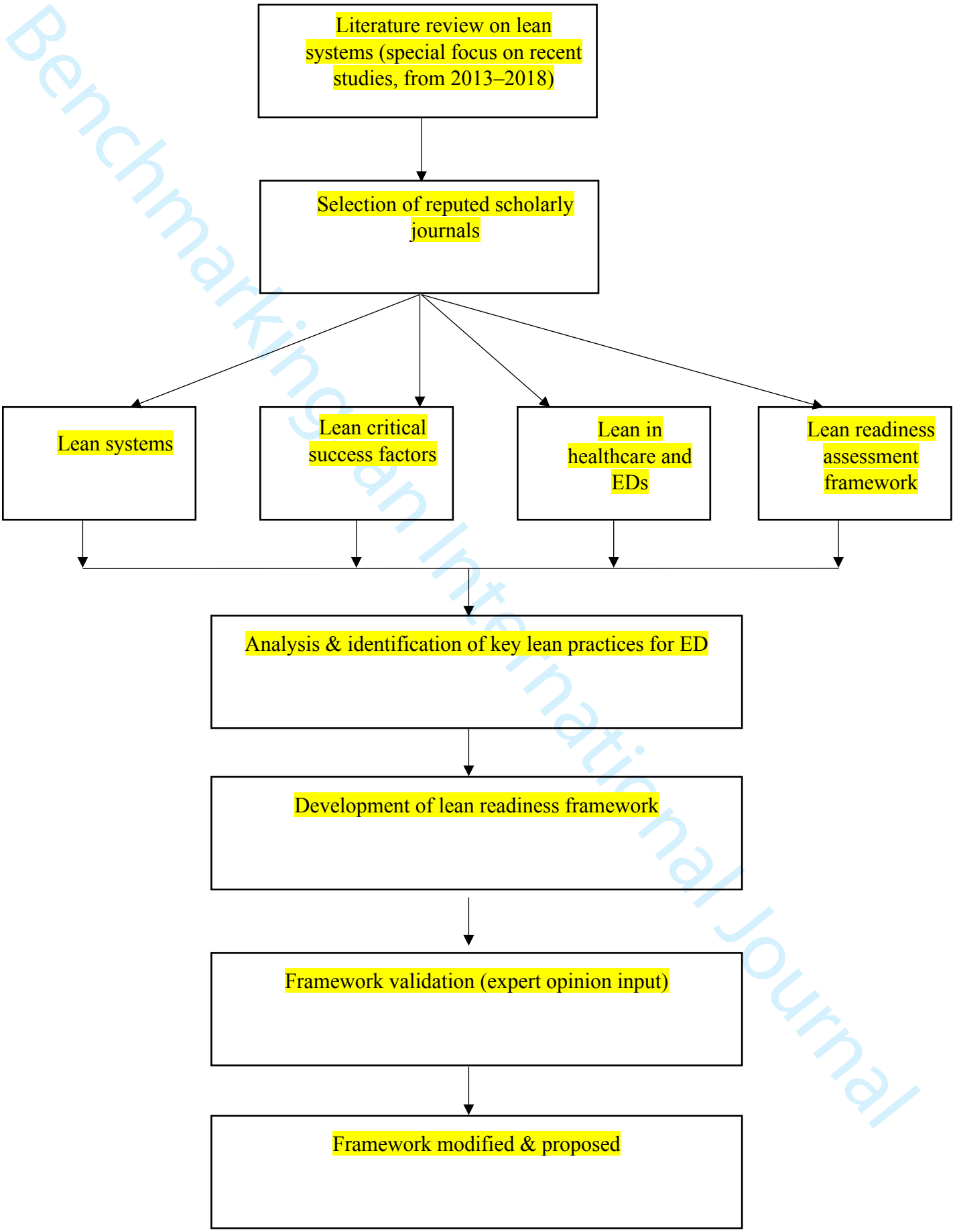


Figure 1 Flow chart of the research methodology

4 Proposed healthcare lean readiness assessment framework and findings

This section explains the rationale behind the development of the HLRA framework. It highlights the important lean readiness categories (top management and leadership, human resources, patient relations, supplier relations, processes, and CI), as found in the literature. It also includes an explanation of each category and element and why it is important for LSs.

4.1 Top management and leadership

Any change should start with a top management initiative and strong leadership to lead the change; indeed, without top management commitment and support, it will be very difficult to start any initiative, let alone succeed in it (Alnajem *et al.*, 2013). Top management support is crucial for LSs because lean requires empowerment, training, and involvement, which require top management buy-in.

Top management and leadership commitment is thus crucial for LSs. This commitment manifests in many forms, such as providing a clear vision, allocating resources and funding, and providing strategic leadership (Tsang and Antony, 2001). To ensure the success of LS implementation, it is essential for top management to create a quality culture by empowering other employees (Rees, 2011). This factor has been emphasised in various healthcare articles. Narayanamurthy *et al.* (2018) declare that top management needs to be well prepared for the lean journey to overcome the challenges therein, and must show strong leadership in communicating the hospital's vision to frontline workers (i.e. nurses and doctors); external consultants can also suggest improvements. Shazali *et al.* (2013) and Spagnol *et al.* (2013) share the same view, and emphasise that lean cannot be implemented without strong top management buy-in and

leadership. Several authors argue that one of the key factors of lean readiness in hospitals is top management leadership (Bushell and Shelest, 2002; Jimmerson *et al.*, 2005; Toussaint, 2009; Chand, 2011; Radnor, 2011; Rees, 2011; Díaz *et al.*, 2012).

To measure ED readiness in this category, several questions were developed that aimed to identify the level of top management commitment in terms of being present in the working area, locating the right people in the right places, providing job security, investing in consultancy and expert advice, and investing in training. Without top management and leadership commitment, LS implementation will not succeed (Alnajem *et al.*, 2012, 2013; Shazali *et al.*, 2013; Narayanamurthy *et al.*, 2018). Table 5 summarises the key areas covered in this category.

This led to the following hypotheses (H):

H1: Top management has a significant impact on processes.

H2: Top management has a significant impact on CI.

Insert table 5 here

4.2 Human resources (doctors, nurses, and other staff)

The heart and soul of any organisation are its people. LSs require competent and multi-skilled people who believe in change and are able to lead, as well as teamwork and communication between departments to reap the benefits of the LS. Training, empowerment, involvement, and recognition are important factors in terms of LS success (Al-Balushi *et al., 20*14; Narayanamurthy *et al.*, 2018), and are required in order to provide high-quality services. Employees are the core of the company and therefore need to be involved in the company's

strategy and direction, especially when implementing LSs. Without skilled workers, LSs will not last (Alnajem *et al.*, 2013).

Narayanamurthy *et al.* (2018) argue that the human resources play a major role in lean readiness in healthcare. Even though LSs and other QIs have to be implemented by top management, human resources are key in implementing, maintaining, and sustaining the change. Al-Balushi *et al.* (2014) and Narayanamurthy *et al.* (2018) explain the important role of human resources in lean implementation within healthcare and argue that lean cannot work without human resources' involvement and engagement. Several authors have noted that human resources play a significant role in preparing a hospital for embracing lean (Bushell and Shelest, 2002; Jimmerson *et al.*, 2005; King *et al.*, 2006; Toussaint, 2009; Chand, 2011; Radnor, 2011; Díaz *et al.*, 2012).

The readiness of human resources was assessed using several questions that aimed to evaluate employee involvement, training, empowerment, and teamwork, as well as incentive and reward systems, communication between employees, and communication between departments. This category represents the core of LSs, as many authors and researchers have stressed the role of human resources. **Error! Reference source not found.** shows the key areas covered in this category.

This led to the following hypotheses:

H3: Human resources have a significant impact on processes.

H4: Human resources have a significant impact on CI.

Insert table 6 here

4.3 Patient relations

Patients should be the starting point for any lean journey in healthcare because they represent the customer, and, according to the five lean principles, the first is step is to define value based on the customer's point of view. Thus, it would be very hard to design any LS in healthcare without a proper understanding of patients, including patient respect, patient feedback, and what does and does not add value to the patient journey in EDs.

As highlighted by many authors, keeping patients happy should be the aim of any hospital, as all departments are ultimately working to satisfy patient needs. To this end, the hospital must understand its patients' requirements (Duggirala *et al.,* 2008; Padma *et al.,* 2009; Radnor 2011; Rees, 2011). Moreover, the hospital needs to respond quickly to patient complaints.

Ben-Tovim *et al.* (2008) assert that it is an essential requirement of LSs in healthcare to specify value from the patient's point of view, and that a lot of quality practices need to be practised by the hospital. Many researchers (Bushell and Shelest, 2002; Jimmerson *et al.*, 2005; King *et al.*, 2006; Toussaint, 2009; Chand, 2011; Radnor, 2011; Shazali *et al.*, 2013; Al-Balushi *et al.*, 2014) emphasise the importance of customer or patient relations in healthcare.

To measure ED readiness regarding patients, several questions were asked that aimed to identify the level of awareness about patients in terms of understanding them, the level of patients' involvement and participation in process improvement, and how the ED deals with

patient complaints (Spagnol *et al.*, 2013). **Error! Reference source not found.** shows the key areas covered in this category.

This led to the following hypotheses:

H5: Patients have a significant impact on processes.

H6: Patients have a significant impact on CI.

Insert table 7 here

4.4 Supplier relations

The fourth principle of LSs is creating 'pull', which is not possible without competent suppliers that provide speedy deliveries and quality shipments that do not require inspection upon arrival.

Again, this factor has been mentioned in many articles. Quality suppliers enable companies to produce quality products (Alnajem *et al.,* 2013); this is important in LSs, as the long-term relationships with suppliers will enable the company to perform just in time (JIT), which is essential for LSs (Dayton, 2001; Found and Harrison, 2012).

With regard to healthcare, Narayanamurthy *et al.* (2018) explain the vital role played by suppliers in hospital readiness towards lean. They insist on the importance of partnerships and supplier involvement. Indeed, JIT and pull systems can be implemented without strong relationships with suppliers. Several authors emphasise the important role of suppliers for lean readiness in healthcare (King *et al.*, 2006; Toussaint, 2009; Chand, 2011; Radnor, 2011; Al-Balushi *et al.,* 2014; Narayanamurthy *et al.*, 2018).

Hospital–supplier relations were evaluated using several questions that aimed to identify the quality of suppliers, the number of suppliers, the suppliers' involvement, and the hospital's long-term relationships with suppliers. According to Narayanamurthy *et al.* (2018), having fewer suppliers and long-term relationships with them, and making suppliers part of the company's team, are essential for healthy LSs. **Error! Reference source not found.** shows the key areas covered in this category.

This led to the following hypotheses:

H7: Suppliers have a significant impact on processes.

H8: Suppliers have a significant impact on CI.

Insert table 8 here

4.5 Processes

Smooth flow is essential to LSs, and can be achieved by removing steps that could delay processes. There are several approaches to this, such as the proper placement of equipment, signage that facilitates patients' movement, and checking equipment regularly.

Process management is one of the most important factors in terms of identifying non-value-adding activities and increasing quality. Ineffective processes lead to more waste and lower productivity per employee (Alnajem *et al.*, 2013).

In healthcare, several researchers (Shazali *et al.*, 2013; Spagnol *et al.*, 2013; Al-Balushi et al., 2014; Narayanamurthy *et al.*, 2018) stress the importance of these factors in terms of matching demand and capacity levels to improve flow, and having a good process design that supports smooth flow.

Several questions were included in this category to evaluate ED practices with respect to whether they support lean practices in terms of process flow, housekeeping, production rate, cycle time, total productive maintenance (TPM), flow of materials, designated areas, and labelled items. **Error! Reference source not found.** shows the key areas covered in this category.

Insert table 9 here

4.6 Continuous improvement (CI)

The second and fifth principles of lean are 'value stream' and 'perfection', which mean that each process needs to be analysed to identify the non-value-adding activities and waste that

are delaying the process. In LSs, this requires continuous checks of each process, workers skilful in problem-solving and benchmarking, etc.

Many authors highlight the importance of these factors. According to Chong and Rundus (2004), the use of quality control systems and scientific methods to solve problems, as well as simple VM, can help to ensure CI, which is key for enhancing a firm's performance and eventually leads to higher levels of customer satisfaction.

With regard to healthcare, several authors (Shazali *et al.*, 2013; Spagnol *et al.*, 2013; Al-Balushi et al., 2014; Narayanamurthy *et al.*, 2018) stress the importance of CI for improvement, including the need for problem-solving abilities, benchmarking best practices, and establishing standards.

This category consisted of several questions, with the aim of shedding light on quality and management practices in terms of solving problems using VM, scientific methods, focus groups, benchmarking, etc. **Error! Reference source not found.** shows the areas covered in this category.

Insert table 10 here

4.7 HLRA conceptual framework

The assessment tools used in this study were inspired by the frameworks set forth by Alnajem *et al.* (2013) and Narayanamurthy *et al.* (2018). These frameworks use different approaches to assess organisational readiness towards LS implementation; however, they could not be used in their present forms, as there was a need to adjust them to fit the purpose of this study.

The framework proposed by Narayanamurthy *et al.* (2018) measures lean readiness within healthcare based on a shareholder perspective. The author believes that this model has some flaws. One flaw is that it does not assess the hospital's current practices, but it does measure the perceptions of stakeholders regarding the importance of some essential lean practices. Thus, the hospital might think that one factor is very important to lean but might not practice it, which could cause confusion in how to assess the hospital's readiness. What if the respondents have not heard of LSs? In addition, the framework requires a 'lean sensei' (a facilitator in the lean journey), so what happens if the hospital does not have an expert in LSs? The author believes that the framework would not indicate whether a hospital has a good foundation for LSs.

Alnajem *et al.* (2013) create a framework to measure lean readiness within Kuwaiti manufacturing industries. They use a simple analysis that identifies organisational readiness based on the size of the firm and quality certification, such as ISO-9000. Thus, not all of the metrics are applicable to measuring lean readiness within EDs. Moreover, neither framework was created to measure lean readiness within EDs, which require certain aspects and quality practices due to their work nature.

The proposed framework measures the quality practices currently used by EDs to identify their readiness to adopt LSs. Moreover, the framework measures the key quality practices deemed essential for implementing or sustaining LSs. Most of these practices are considered building blocks of LSs, such as 5S, VM, benchmarking, process flow support, etc. Furthermore, the proposed framework allows ED managers to understand the relationships between the categories and how they affect ED lean readiness.

The Royal College of Emergency Medicine has developed best practice guidelines that need to be followed by medical and nursing staff in EDs to provide world-class care to patients. The guidelines focus on key areas, such as the ED team, the patient pathway through the ED, measuring care and leadership, and education about care. Most of these items are highly related to quality practices and LSs, so they were incorporated in the development of the HLRA framework for EDs. These practices are the key tenets of the five lean principles that, if followed, will help EDs to eradicate all types of waste.

The proposed framework does not aim to assess the leanness of EDs, but rather to evaluate EDs' quality and management practices and to allow ED managers to see whether their EDs have the capabilities to implement LSs. Table 11 summarises the essential lean practices that were identified in the lean healthcare literature and used in this study.

Insert table 11 here

Based on the literature, the prerequisite quality practices were grouped into six main categories, divided into three groups:

- First group: includes the internal quality practices, which consist of the independent variables (IVs) of top management/leadership and human resources.
- Second group: includes the external quality practices, which consist of patient and supplier relations that act as moderating factors.
- Third group: includes the internal technical quality practices, which consist of the dependant variables (DVs) of processes and CI.

The author conceptualised top management/leadership and human resources as internal practices that are needed for LSs. The external factors are patient and supplier relations, which

influence the readiness for LSs. The DVs of processes and CI were used as predictors/indicators of lean readiness. The literature shows that the internal and external practices (i.e. top management, human resources, and patient and supplier relations) significantly influence and impact ED readiness towards LSs.

This framework allows us to understand the relationships between the variables and the lean readiness within EDs. Several analyses were conducted to understand these relationships. Figures 2–6 show the conceptual diagrams of the HLRA framework.

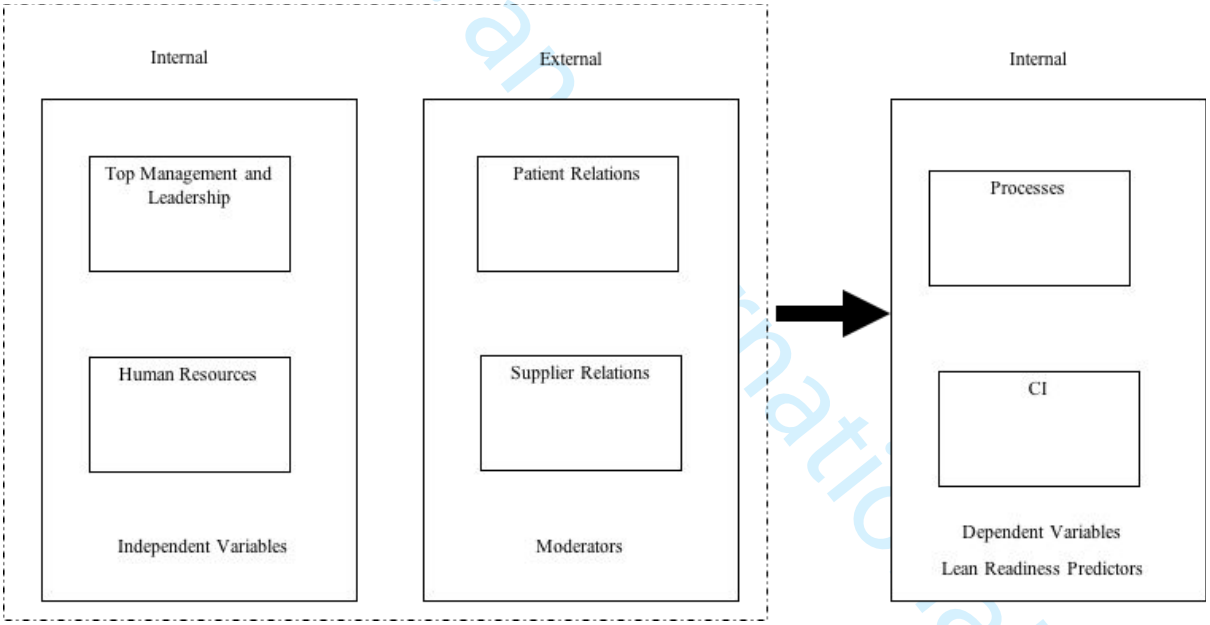


Figure 2: HLRA conceptual framework

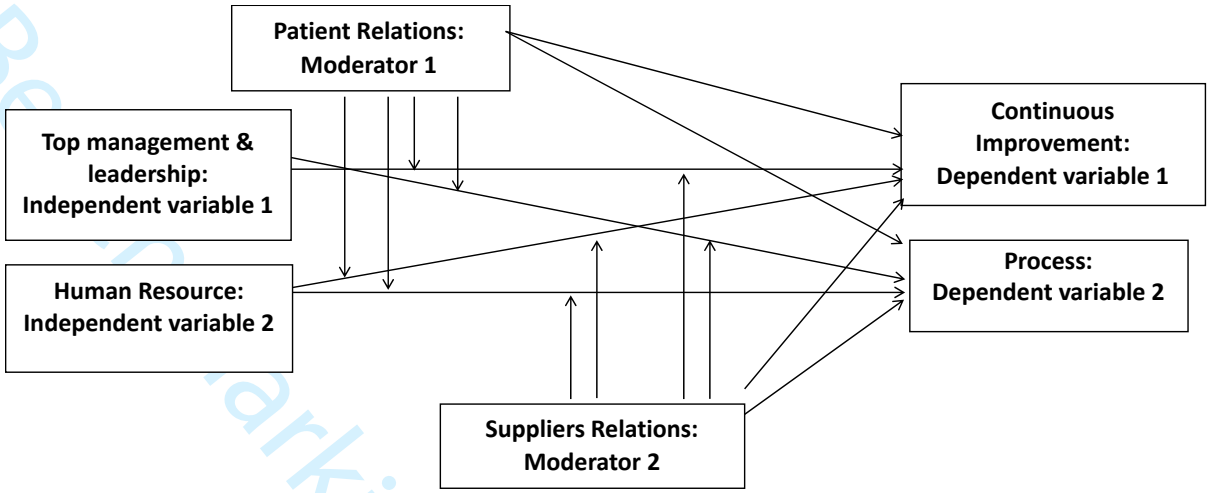


Figure 3: Relationships between the variables in the HLRA framework

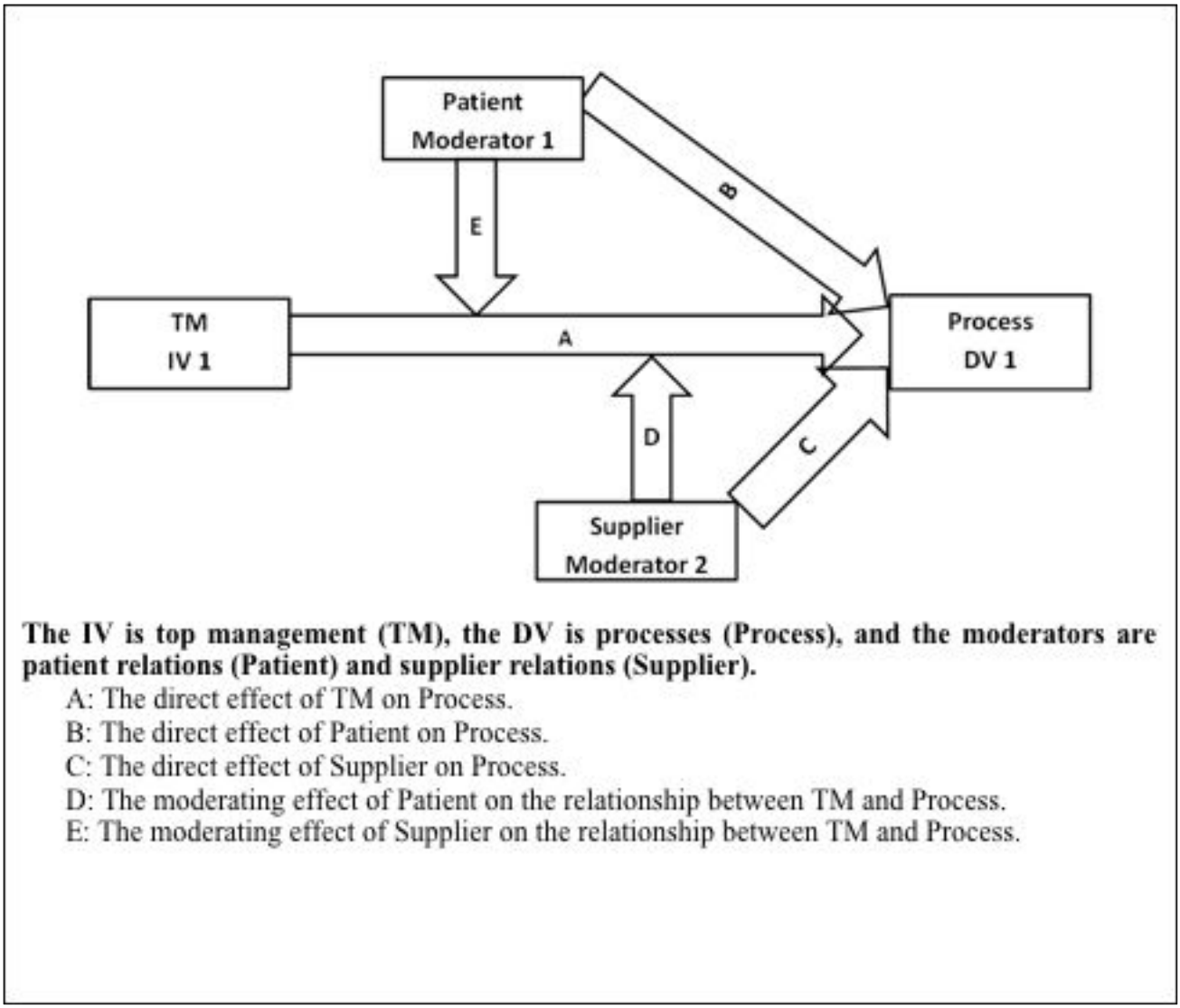


Figure 4 Model 1: The moderating effects of (i) patient relations and (ii) supplier relations on the effect of top management on processes

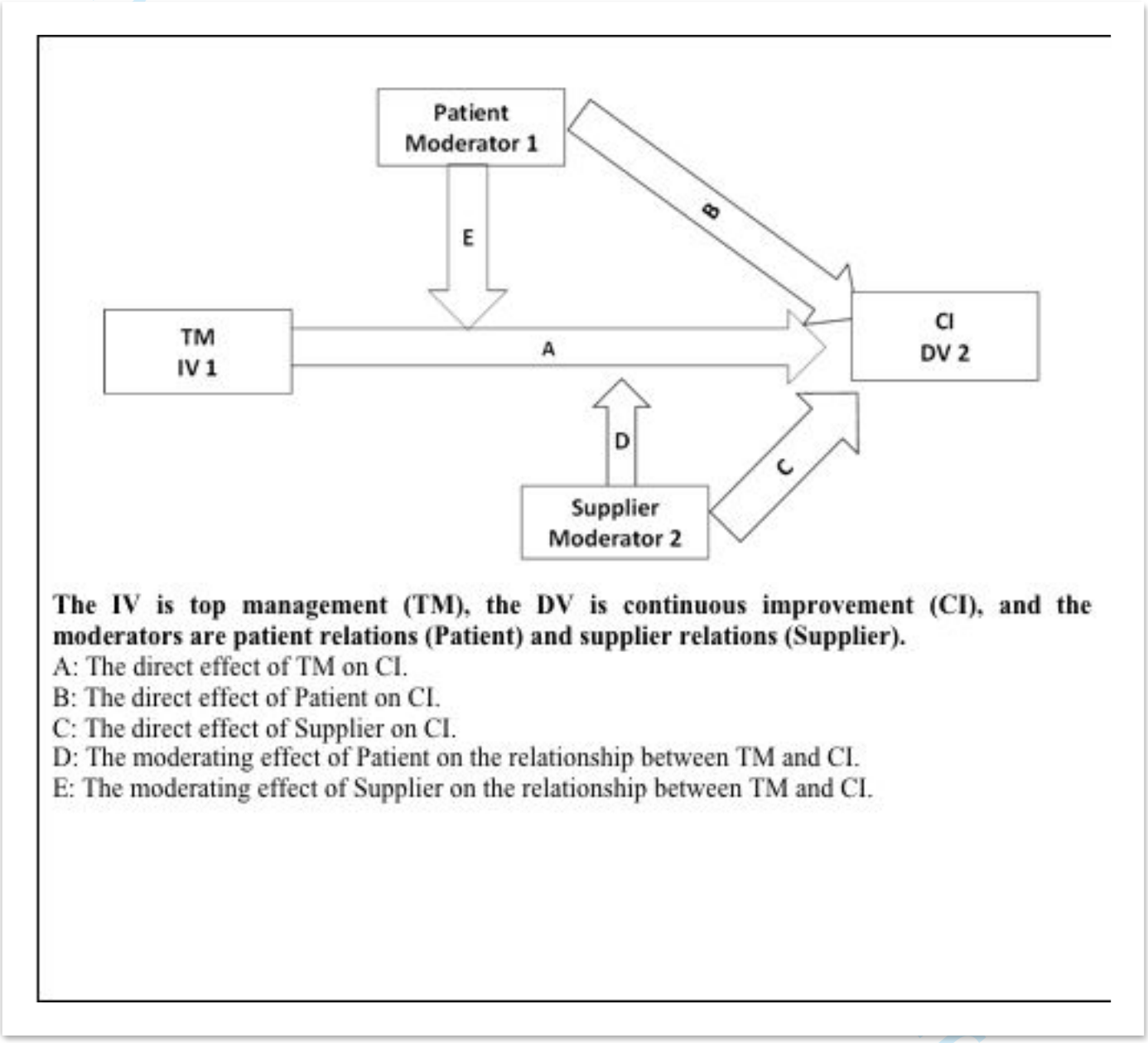
This led to the following hypotheses:

H9: Patient relations have a moderating effect on the relationship between top management and processes.

H10: Better patient relationships will improve the effect of top management on processes.

H11: Supplier relations have a moderating effect on the relationship between top management and processes.

H12: Better supplier relationships will improve the effect of top management on processes.



The IV is top management (TM), the DV is continuous improvement (CI), and the moderators are patient relations (Patient) and supplier relations (Supplier).
A: The direct effect of TM on CI.
B: The direct effect of Patient on CI.
C: The direct effect of Supplier on CI.
D: The moderating effect of Patient on the relationship between TM and CI.
E: The moderating effect of Supplier on the relationship between TM and CI.

Figure 5 Model 2: The moderating effects of (i) patient relations and (ii) supplier relations on the effect of top management on CI

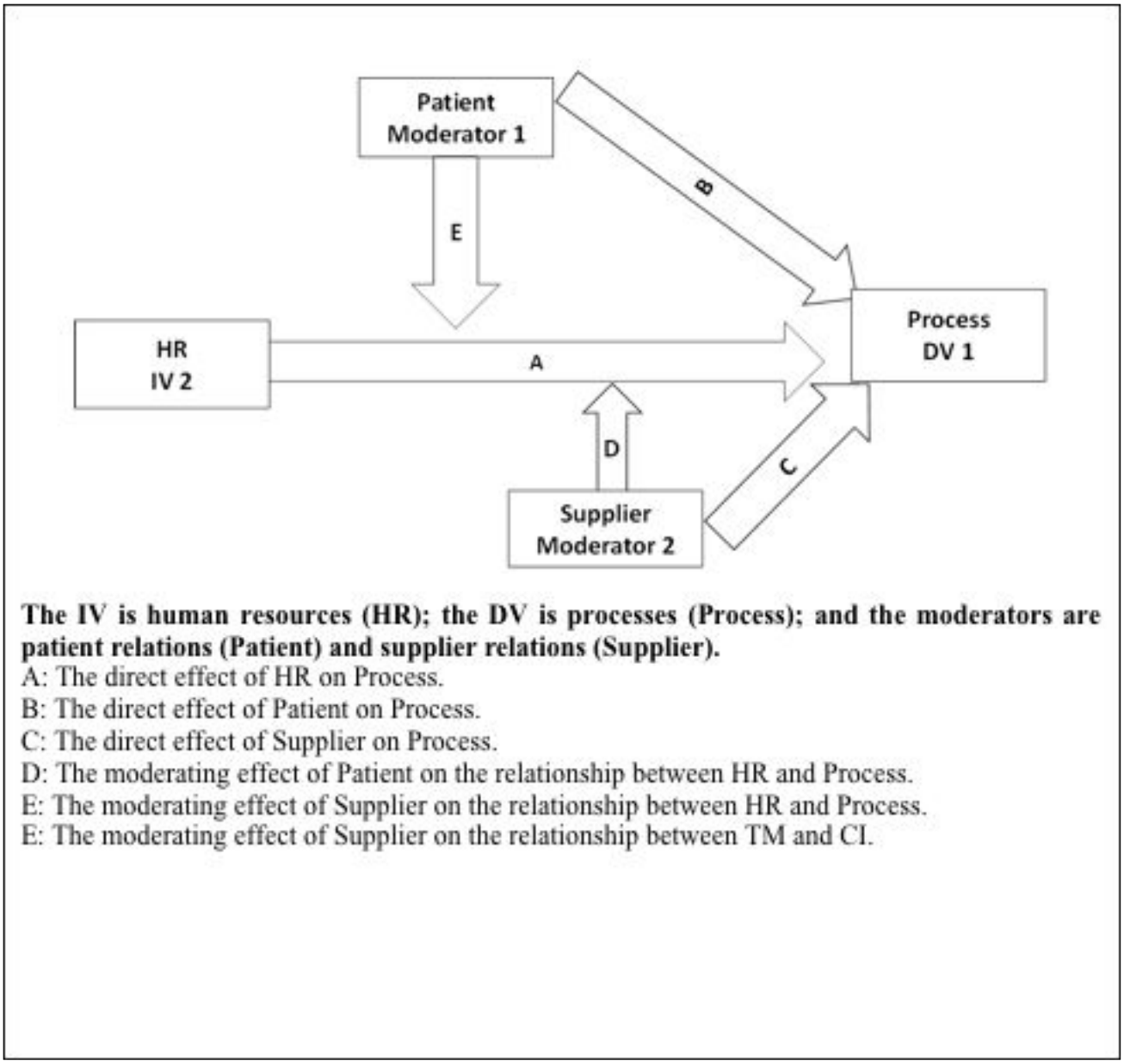
This led to the following hypotheses:

H13: Patient relations have a moderating effect on the relationship between top management and CI.

H14: Better patient relationships will improve the effect of top management on CI.

H15: Supplier relations have a moderating effect on the relationship between top management and CI.

H16: Better supplier relationships will improve the effect of top management on CI.



The IV is human resources (HR); the DV is processes (Process); and the moderators are patient relations (Patient) and supplier relations (Supplier).
A: The direct effect of HR on Process.
B: The direct effect of Patient on Process.
C: The direct effect of Supplier on Process.
D: The moderating effect of Patient on the relationship between HR and Process.
E: The moderating effect of Supplier on the relationship between HR and Process.
E: The moderating effect of Supplier on the relationship between TM and CI.

Figure 6 Model 3: The moderating effects of (i) patient relations and (ii) supplier relations on the effect of human resources on processes

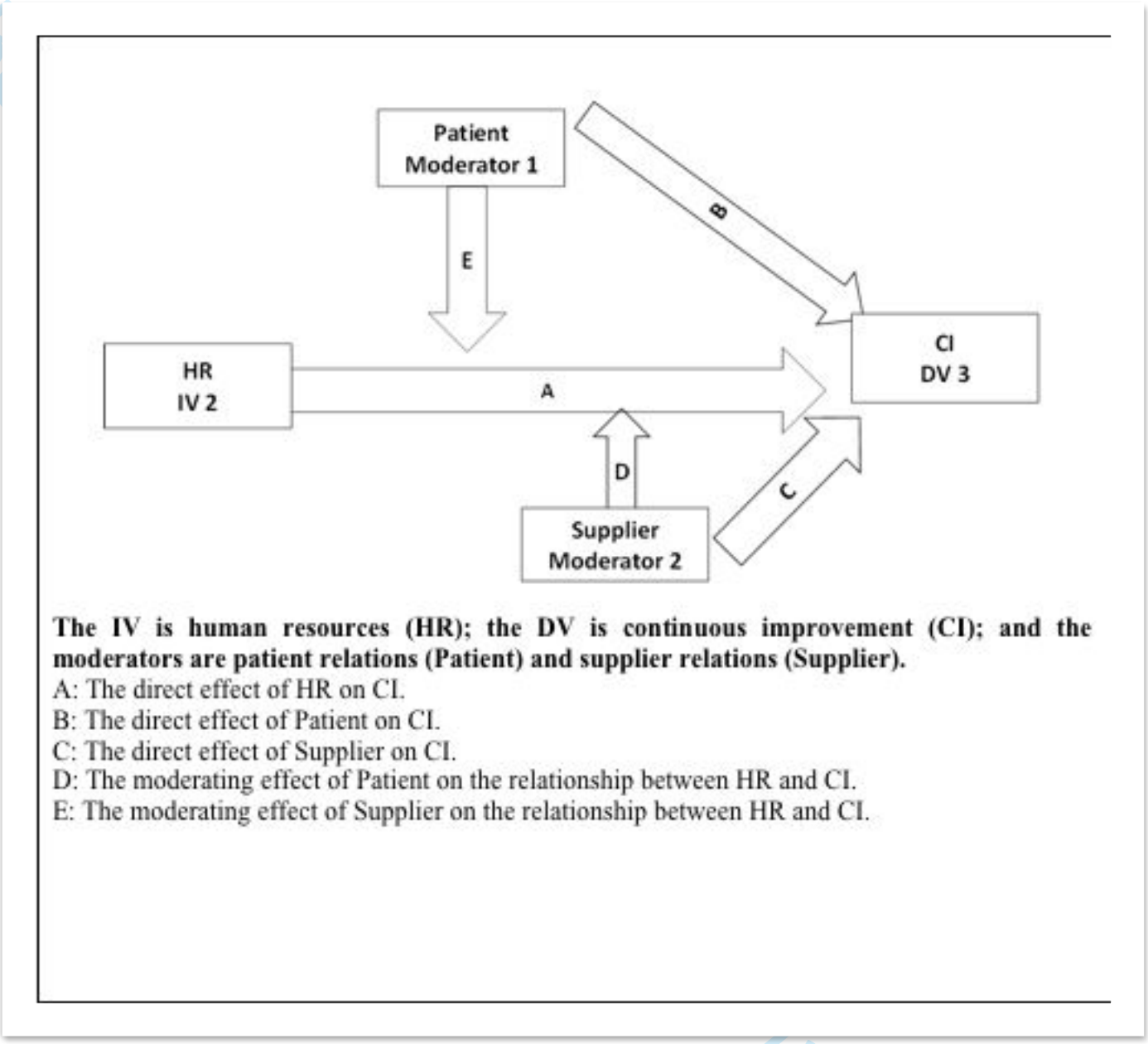
This led to the following hypotheses:

H17: Patient relations have a moderating effect on the relationship between human resources and processes.

H18: Better patient relationships will improve the effect of human resources on processes.

H19: Supplier relations have a moderating effect on the relationship between human resources and processes.

H20: Better supplier relationships will improve the effect of human resources on processes.



The IV is human resources (HR); the DV is continuous improvement (CI); and the moderators are patient relations (Patient) and supplier relations (Supplier).
A: The direct effect of HR on CI.
B: The direct effect of Patient on CI.
C: The direct effect of Supplier on CI.
D: The moderating effect of Patient on the relationship between HR and CI.
E: The moderating effect of Supplier on the relationship between HR and CI.

Figure 7 Model 4: The moderating effects of (i) patient relations and (ii) supplier relations on the effect of human resources on CI

This led to the following hypotheses:

H21: Patient relations have a moderating effect on the relationship between human resources and CI.

H22: Better patient relationships will improve the effect of human resources on CI.

H23: Supplier relations have a moderating effect on the relationship between human resources and CI.

H24: Better supplier relationships will improve the effect of human resources on CI.

5 Discussion, conclusion, and implications

The extensive literature review allowed the author to identify several lean readiness factors deemed essential for LS implementation within the healthcare sector, and specifically in EDs, including: employee empowerment, training, top management commitment, the use of problem-solving tools, VM, patient involvement, the quality of suppliers, etc. (Bushell and Shelest, 2002; Radnor *et al.*, 2011; Shazali *et al.*, 2013; Al-Balushi *et al.*, 2014; Narayanamurthy *et al.*, 2018). This helped to address the first research question: 'what are the prerequisites that EDs have to satisfy to be ready for lean implementation?'

After deep analysis of these factors, they were clustered into six main categories (top management and leadership, human resources, patient relations, supplier relations, processes, and CI). This enabled the author to develop an HLRA framework to address the second research question: 'how can lean readiness within EDs be assessed?'

Given the importance of readiness prior to LS adoption (Radnor *et al.*, 2011; Al-Balushi *et al.*, 2014; Narayanamurthy *et al.*, 2018), this study provides a new perspective on assessing lean readiness within EDs. This framework could save effort and other resources, as it gives clear guidance on the important aspects of LSs for EDs prior to implementation. Furthermore, it could guide managers to identify ED weaknesses and to try to address them before attempting LS implementation. The literature review highlighted the lack of lean studies within healthcare

and, more precisely, within EDs; it also showed the lack of frameworks for measuring lean readiness in general (Alnajem *et al.*, 2013), and lean readiness in the healthcare industry more specifically (Narayanamurthy *et al.*, 2018). This study fills this gap and proposes a unique HLRA framework, which can be modified or amended to the needs of different hospital departments. This study is unique and pioneering in terms of developing an HLRA framework for the healthcare sector.

One limitation of this study is that, due to time constraints, it was not possible to validate the HLRA framework in EDs that had already implemented LSs to use as a benchmark. This prevented the author from validating the framework and explicitly stating that this model is the best fit for EDs that want to assess their lean readiness.

The HLRA framework provided here is simple to use, and will allow ED managers to understand their current practices to see whether they are supportive of LSs or if aspects need to be addressed before implementation. This will make it possible for managers to understand whether they have the required resources for LSs. For example, by using the HLRA framework managers will be able to assess whether they have tidy workplaces, labelled items, TPM, records of cycle times, skilled workers, employee empowerment, investment funds for training, etc. If managers are not willing to implement these, they will have a minimal chance of success in LS implementation, as LSs require most of the aspects mentioned. The framework is not limited to use in EDs, as most of the items are applicable to all types of hospital department.

A conceptual framework for healthcare lean readiness assessment, based on the experts' opinion and literature review demonstrated in Figure 2, was conducted. The framework conceptualises lean readiness on six dimensions; namely, top management/leadership, HR, patient relations, supplier relations, suppliers' process, and CI. The dimensions were explained in

section 3. The proposed instrument for measuring these dimensions is provided in the appendix. Items have been significantly modified in order to suit the context of ED context.

The instrument developed can be used by ED administrators and managers of healthcare institutions to measure their lean readiness. A five-point Likert scale (ranging from 1 = 'strongly disagree' to 5 = 'strongly agree') was used to measure the current quality practices, and one additional option, 'Not aware', was included to enable the respondents to indicate a lack of awareness of certain practices or policy. A score of less than 4 in a dimension indicates a low readiness level, as indicated by Alnajem et al. (2013), and thus a need for the hospital to improve its quality practices with respect to that dimension. Therefore, EDs can compare their performance in terms of the dimensions and their lean readiness with the benchmarks for lean quality practices. EDs can also use the framework to monitor their performance over time. Further, hospitals can conduct functional benchmarking using the quality practice dimensions across departments.

Several analyses can be conducted in future to further understand ED lean readiness. A multiple regression analysis with process and CI as the DVs, and top management and HR as IVs, would aid in identifying EDs' lean readiness level. Structural equation modelling can also be used to understand the moderating effect of:

- Patient relations on the effect of top management on process;
- Patient relations on the effect of top management on CI;
- Supplier relations on the effect of top management on process;
- Supplier relations on the effect of top management on CI;
- Patient relations on the effect of HR on process;

- Patient relations on the effect of HR on CI;
- Supplier relations on the effect of HR on process; and
- Supplier relations on the effect of HR on CI.

This paper makes two broad conceptual contributions. First, it explores lean quality practices for successful implementation of lean, and second, it provides a brief description of six main lean quality practices categories that will be helpful for further studies. Although ample literature is available on lean and the various issues related to it, the relationship between lean quality practices and the current ED quality practices has not been modelled for healthcare organizations. The present framework will help managers and lean practitioners to understand the relationship between the essential lean quality practices in detail. This represents an important contribution of the present research. Another contribution is the fact that the study compiles literature that practitioners can use in designing structurally robust lean implementation strategies.

This study highlights a number of avenues for further empirical research; as a first step, the framework needs to be applied to successful lean implementations in EDs in order to establish valid benchmarks. Other suggested avenues for future research include encouraging other researchers to conduct similar studies and creating different lean readiness assessment frameworks for different sectors.

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Insert appendix here

Lean readiness within emergency departments: A conceptual framework

Table 1: Lean benefits in the healthcare literature

Benefit	Authors
Reduced waiting times for patients	Cooke *et al.* (2002); Bushell and Shelest (2002); King *et al.* (2006); Kelly *et al.* (2007); Banerjee *et al.* (2008); Ieraci *et al.* (2008); Dickson *et al.* (2009); Ng *et al.* (2010)
Improved flow or admission into hospital wards	Bushell and Shelest (2002); Banerjee *et al.* (2008); Ieraci *et al.* (2008); Baumlin *et al.* (2010)
Increasingly functional workplaces through order and standards	King *et al.* (2006); Ballé and Régnier (2007); Lodge and Bamford (2008); Dickson *et al.* (2009)
Better employee morale	Bushell and Shelest (2002); Papadopoulos (2011)
Reduced costs	Toussaint (2009); Papadopoulos (2011); Folinas and Faruna (2011)
Improved patient satisfaction	Folinas and Faruna (2011); Garcia (2014)

Table 2: Waste types and healthcare examples.

Waste type	Healthcare examples
Transportation	• Staff walking to the other end of a ward to pick up notes • Central equipment stores for commonly used items instead of locating items where they are used
Inventory	• Excess stock in storerooms that is not being used • Patients waiting to be discharged • Waiting lists
Motion	• Unnecessary staff movement looking for paperwork • Not having basic equipment in every examination room
Waiting	• Waiting for patients, theatre rooms, staff results, prescriptions,

	and medicine • Waiting for doctors to discharge patients
Over-production	• Requesting unnecessary tests from pathology • Keeping investigation slots 'just in case'
Over-processing	• Duplication of information • Asking for patients' details several times
Defects	• Re-admission because of failed discharge • Repeating tests because correct information was not provided

Source: NHSIII (2007)

Table 3: Lean tools applied in healthcare

Lean tool applied in healthcare	**Authors**
PDSA cycles or A3 problem-solving projects	Bushell and Shelest (2002); Walley and Gowland (2004); Jimmerson *et al.* (2005); King *et al.* (2006); Toussaint (2009); Radnor (2011); Chand (2011)
Standardised work and 5S	Weber (2006); Ballé and Régnier (2007); Esain *et al.* (2008); Chand (2011); Toussaint (2009)
Kaizen or rapid improvement events	Radnor *et al.* (2006); Fillingham (2007); Kaplan and Patterson (2008); Toussaint (2009); Radnor (2011)
Statistical control charting	Walley *et al.* (2006); Ryckman *et al.* (2009)
Visual control	Bushell and Shelest (2002); Ballé and Régnier (2007)
Value stream mapping	Jones and Mitchell (2006); Kim *et al.* (2009); Smith (2009)
Five whys	Jimmerson *et al.* (2005)
One-piece flow	King *et al.* (2006); Chand (2011)
Quality at source	Chand (2011)
Poke-yoke	Díaz *et al.* (2012)

Table 4: Lean assessment frameworks

Authors	Assessment purpose and approach
Sohal and Egglestone (1994)	Assessed the level of lean implementation within Australian firms based on five key areas: inventory; human resources; product design; suppliers; and methods.
Boyer (1996)	Considered four types of investment in the manufacturing infrastructure: quality leadership on the part of management; the use of small groups or teams for problem solving; training; and worker empowerment.
Karlsson and Åhlström (1996)	Created an assessment tool based on nine key areas: elimination of waste; CI; multifunctional teams; vertical information systems; decentralised responsibilities; integrated functions; pull; zero defects; and JIT.
Panizzolo (1998)	Explored how lean has been adopted by Italian firms, based on six areas categorised as internal or external: human resources; processes and equipment; planning and control; product design (internal factors); suppliers; and customers (external factors).
Shahram (2008)	Investigated the level of lean adoption by assessing current practices within Chinese firms in different sectors, based on nine key areas: inventory; team approach; processes; maintenance; layout/handling; suppliers; setup; quality; and scheduling and control.
Gurumurthy and Kodali (2009)	Developed a measurement formwork and benchmarked investigated firms against Toyota, based on eight key areas that contain 65 practices: design; production engineering; suppliers; production planning and control; operation; quality; top management; and human resources.
Wong *et al.* (2009)	Investigated the adoption and implementation of LSs within different organisations in Malaysia, based on 14 key areas: work processes; scheduling; inventory; equipment; layout; material handling; employees; quality; product design; suppliers; tools and techniques; customers; ergonomics and safety; and management and culture.
Nordin *et al.* (2010)	Explored the extent of lean implementation within Malaysian automotive firms; followed Panizzolo's (1998) approach by using external and internal factors. Their study was based on five key areas: processes and equipment; manufacturing planning and

	control; human resources (internal factors); customer relations; and supplier relations (external factors).
Saurin *et al.* (2011)	Assessed the use of lean production within manufacturing cells, based on three key areas that include 18 practices: human resources; planning and control; and process technology.
Stone (2012)	Developed a framework to measure the leanness of an organisation based on organisational change and organisational performance in medium-sized manufacturing firms. Considered 12 key areas: external environment; mission and strategy; leadership; culture; individual and organisational performance; task requirements and individual skills/abilities; management practices; systems; work group climate; motivation; structure; and individual needs and values.
Saleeshya *et al.* (2013)	Assessed lean based on a conceptual model. Measured the enabling factors that support lean within an organisation, based on lean principles grouped into seven categories: value; value stream; flow; pull; perfection; robust products and processes; and human aspects.
Karim and Arif-Uz-Zaman (2013)	Developed a measurement framework to assess continuously the efficiency and effectiveness of lean implementation based on five lean principles: value; value stream; flow; pull; and perfection.
Alnajem *et al.* (2013)	Developed a lean readiness model to measure lean readiness within Kuwaiti manufacturing industries. Their assessment was based on six main constructs: processes; planning and control; human resources; suppliers; customer relations; and top management and leadership.
Narayanamurthy *et al.* (2018)	Used stakeholder theory to develop a lean readiness framework for healthcare. Their assessment was based on a stakeholder perspective (leadership and executive team, frontline management team, lean team, patients, suppliers, and healthcare institution).
Sangwa and Sangwan (2018)	Proposed a measurement framework to measure the effect of lean implementation throughout all functions of an organisation. Their measurement was based on seven categories: manufacturing processes; new product development; human resource management; finance; administration; customer management; and supplier management.

Table 5: Top management and leadership – critical quality practices

Top management and leadership factor	Definition	Sources
Visible management	• It is essential in LSs for top management to be visible in the workplace to motivate people. • Top management must be motivated and committed towards improvement, as this will stimulate workers.	Bushell and Shelest (2002); Jimmerson *et al.* (2005); Toussaint (2009); Chand (2011); Radnor (2011); Rees (2011); Díaz *et al.* (2012); Narayanamurthy *et al.* (2018); Sangwa and Sangwan (2018)
Investment and commitment to improvement	• LSs require investment in training, consultancy, and hiring experts to improve the work, and this entails commitment from managers and leaders who believe in improving the system.	
Knowing people's capabilities	• In order to get the best from its people, the organisation needs to understand their capabilities and assign them to jobs that best match their skills.	

Table 6: Human resources – critical quality practices

Human resource factor	Definition	Sources
Involvement and participation	• Involvement and participation have been emphasised in the literature, as LSs require everyone in the organisation to be involved by providing suggestions to improve the system; to do this, employees need to be aware of their roles in the organisation.	Bushell and Shelest (2002); Jimmerson *et al.* (2005), King *et al.* (2006); Toussaint (2009); Chand (2011); Radnor (2011); Rees (2011); Díaz *et al.* (2012); Al-Balushi *et al.* (2014); Narayanamurthy *et al.* (2018); Sangwa and Sangwan (2018)
Skills and multi-skilled workers	• Workers need to be skilled to participate in improving the system and to contribute to problem-solving; further, LSs require multi-skilled people who are able to perform different tasks.	
Training	• In order to perform different tasks and contribute to problem-solving, workers need to be trained in problem-solving and cross-trained in different sections of the company.	
Motivation	• Motivation is essential to encourage people to participate and provide new ideas; workers need to be highly motivated and rewarded for their efforts, and this can done via empowerment and by having clear rewards and incentives.	
Communication	• Effective communication between employees and departments is essential. Without it, LSs cannot be successful, as communication enables workers to understand their job requirements and avoid conflict with other departments (e.g. there has to be communication between the sales and production departments, as the sales department needs to understand the capacity of the production department). This could save the organisation time and money.	
Teamwork	• Teamwork is needed in LSs, as it will help employees to share knowledge and ideas. According to AlNajem *et al.* (2013), teamwork helps to improve work by providing suggestions to develop processes, which is essential for CI. It also creates competition between workers,	

which can motivate them.

Table 7: Patient relations – critical quality practices

Patient relations factor	Definition	Sources
Understanding the patients	• The organisation must understand its customers' needs and requirements and must ensure that production is in line with customers' orders and demands, as LSs are about creating the value that customers are willing to pay for, with any excess considered waste.	Spagnol *et al.* (2013); Shazali et al. (2013); Al-Balushi *et al.* (2014); Narayanamurthy *et al.* (2018); Sangwa and Sangwan (2018)
Patients' involvement	• The organisation needs to build relationships with its customers in order to understand them. This can be done by involving them in product design, which will ensure that they will be willing to pay for the product.	
	• In order for the company to produce based on customer demand (pull and just in time), strong relations and mutual trust must be built with customers.	
	• Customers' complaints need to be taken seriously to avoid future mistakes and to retain the customer base.	
Patient feedback	• To retain customers, the organisation should involve them and use their feedback and suggestions.	

Table 8: Supplier relations – critical quality practices

Supplier relations factor	Definition	Source
Quality suppliers	• The quality of suppliers is very important for LSs. Quality means providing goods on time, without need for further inspection. To this end, the organisation should have a clear strategy for dealing with suppliers.	King *et al.* (2006); Toussaint (2009); Chand (2011); Radnor (2011); Al-Balushi *et al.* (2014); Narayanamurthy *et al.* (2018); Sangwa and Sangwan (2018)
Supplier location	• This aspect is very important, as many authors suggest dealing only with suppliers in close proximity to enable them to perform JIT manufacturing effectively.	
Number of suppliers	• Many authors have emphasised dealing with few suppliers or a single supplier for each item, as this will help in building long-term relationships with suppliers, which will make the suppliers more committed to supplying quality products and providing JIT delivery.	
Supplier relationships	• Maintaining long-term relationships with suppliers is essential in LSs, as it will reflect positively in supplier performance and in terms of finances. Many authors have stressed the importance of relationships with suppliers as a critical factor for lean implementation and JIT manufacturing.	
Supplier involvement	• It is highly recommended to involve suppliers in areas such as product design and development, inventory management, etc. This could help organisations to improve the quality of their products.	
Supplier feedback	• Shah and Ward (2007) emphasise providing suppliers with regular feedback on deliveries and the quality of products, as this will help to improve the relationship and avoid mistakes in the future.	

Table 9: Processes – critical quality practices

Process factor	Definition	Source
Housekeeping (5S)	• The workplace must be tidy and well organised. • Items and equipment should be labelled to ensure that they are located in the right zones. • The organisation needs to have an auditing routine to ensure that every item is returned to where it belongs so that it can be found easily, avoiding 'motion waste'.	Shazali *et al.* (2013); Spagnol *et al.* (2013); Al-Balushi *et al.* (2014); Narayanamurthy *et al.* (2018); Sangwa and Sangwan (2018)
Cellular manufacturing	• The processes should be designed to help the flow, so equipment/items must be placed where they are needed and processes using similar activities should be conducted close to each other to eliminate unnecessary movement.	
Skilled workers running and leading the process	• Each process should be operated by qualified people.	
TPM	• Routine maintenance should be performed by skilled people. • Equipment records should be shown on the shop floor to avoid confusion and to keep employees up to date, which will mitigate the risk of equipment breakdown.	
Documentation	• The organisation should have a well-documented system that includes machine settings and any information needed to change these. • To improve, the organisation should revise the cycle time for each process on a regular basis.	
Creating a pull system	• To avoid excess inventory, the hospital should not use beds to hold dischargeable patients or over-order material to compensate for erratic supply.	

Table 10: CI – critical quality practices

CI factor	Definition	Source
Problem-solving	• Using problem-solving techniques is key to helping the organisation with respect to CI. Problem-solving requires skilled people and should be conducted in groups, which will help to reduce waste within the organisation.	Eller (2009); Shazali *et al.* (2013); Spagnol *et al.* (2013); Al-Balushi *et al.* (2014); Narayanamurthy *et al.* (2018); Sangwa and Sangwan (2018)
Benchmarking	• To improve, the organisation needs to be aware of its competitors. Benchmarking performance against other top-class businesses will allow the organisation to understand any threats from competitors, which could drive improvement.	
Standardised activities	• To avoid misunderstandings regarding work processes and procedures, which could result in waste, the organisation should implement standards, such as specific routes for loading raw materials and removing end products and standard picking times.	
VM	• Managing the workplace visually is highly recommended by lean, as it can help to keep the process smooth and reduce defect rates; this can take many forms, such as identifying the defect rate, key performance indicators, next job activity, etc.	

Table 11: Lean prerequisite quality practices in the healthcare sector

Authors	Top management and leadership	Human resources	Patient relations	Supplier relations	Processes	CI
Bushell and Shelest (2002)	*	*	*		*	*
Jimmerson *et al.* (2005)	*		*		*	*
Golden (2006)	*					*
King *et al.* (2006)			*	*		*
Fillingham (2007)	*	*			*	*
Papadopoulos and Merali (2008)		*				*
Ben-Tovim *et al.* (2008)	*	*				
Toussaint (2009)	*	*	*	*	*	*
de Souza and Pidd (2011)	*					*
Chand (2011)	*	*	*	*	*	*
Radnor (2011)	*	*	*	*	*	*
Rees (2011)	*	*	*	*	*	*
Díaz *et al.* (2012)	*				*	
Spagnol *et al.* (2013)	*	*	*		*	*
Shazali *et al.* (2013)	*	*	*		*	*
Al-Balushi *et al.* (2014)	*	*	*	*	*	*
Narayanamurthy *et al.* (2018)	*	*	*	*	*	*

Sangwa and Sangwan (2018)	*	*	*	*	*	*

Appendix

Top Management and Leadership (TM)

1	The top management has an effective quality improvement plan
2	Top management doesn't promote a quality culture within the hospital
3	There are clear quality goals identified by top management
4	Top management is committed to quality improvement at all levels
5	Top management is not only committed but also involved to improve the work environment
6	Top management make the best use of experience and knowledgeable employees in improving quality
7	Top management is making sure that staff are clear on who to escalate to and how to access members of the senior leadership team and aware of plan and the quality goals.
8	All new or reviewed processes and procedures are developed with staff and communicated effectively with an opportunity for evaluating their effectiveness.
	HR (stakeholders)
9	Employees are not very committed to the success of our hospitals
10	Employees are actively involved in quality-related activities
11	Most of our employee have had training in quality principles.
12	Resources and budget are available for employee quality training
13	Employees work closely together as a team in order to coordinate work and improve quality
14	Management is more in favour of team recognition rather than individual recognition
15	Awards, incentive programmes and annual bonuses are available for employees who help to improve processes and eliminate unnecessary steps (waste).
16	Each employee in our hospital has a clear understanding of their job description.
17	Our staff doesn't feel valued in our hospital
18	Our staff are encouraged to report concerns regarding care
19	Our staff are aware and well trained in how to respond to patients or relatives who wish to complain
20	We often work with members from a variety of departments
21	Our staff know the procedure to follow when they do not believe their concerns have been listened to
	Patient Relations
22	A summary of patients complaints is given to the people in charge (Ward Manager/Charge Nurses/operating people)
23	The Ward Manager/ Charge Nurses are not aware of the level of patients satisfaction
24	The hospital's management uses patients' feedback to improve service quality
25	Quality-related patients' complaints are not treated with priority
26	Patients' requirements are used as the basis for measuring quality.
27	The hospital conducts patient satisfaction surveys on a regular basis
28	Patient feedback is sought and acted upon.

29	The patients' comments positive/negative are shared with all staff
30	Patients, arriving by any means are greeted by a named person
31	Patients are clearly told how to access staff when they have needs or concerns and this access facilitated by the department, to make it as easy as possible
	Supplier Relations
32	A clear strategy is in place by which to evaluate supplier performance in terms of quality, delivery and prices.
33	Local suppliers are preferred where possible to avoid shipment delays.
34	Purchased drug and medicine supplies are not subject to incoming inspection as they come from qualified suppliers.
35	Active steps are taken to reduce the number of suppliers in each category.
36	Drugs, medicine and supplies are received on time from the date of order.
37	Suppliers are not cooperative and committed to maintaining a long-term relationship.
38	Suppliers are provided with feedback regarding quality and delivery performance.
39	The quality of suppliers that we are dealing with is not very good.
	Process (PR)
40	We have a program/system to identify wasted time and costs in all processes
41	The processes (treatment) requiring similar operations (steps) are placed close to each other in order to eliminate unnecessary movement.
42	Each working zone is controlled and operated by qualified and well-trained workers.
43	Each item/piece of equipment is labelled to ensure it is located in the right zone/location in the workplace.
44	A certain person is assigned as a part of his/her daily job to ensure that the workplace is clean and all tools/pieces of equipment are put back in their appropriate places.
45	Equipment maintenance records are not posted on the workplace to be actively shared with employees.
46	Machine operators and staff are not engaged in the scheduled maintenance of equipment so that machines are maintained on a regular basis by skilled people.
47	There is a well-documented configuration setting for each machine/piece of equipment to avoid uncertainty about how to reconfigure the equipment during changeover.
48	Treatment time is revised for each process on a regular basis in order to reach the optimum level.
49	We have designed the patient journey to improve access and reduce waiting times
50	The triage office is located next to the reception area to reduce patient movement
51	There is sufficient signage and information for the patients, to enable easy navigation to, through and from the ED.
52	The equipment in the department are easy to locate, clearly organised and labelled
53	Triage is performed at the field, and at the beginning of process to facilitate and simplify the classification of patients and capture data
54	We have a proper system to avoid holding patients that could be discharged or over ordering material to compensate for erratic supply.
55	We have a proper scheduling system to avoid over ordering material that already available.

	Continuous Improvement (CI)
56	KPI are defined for core processes in order to make improvement.
57	Change initiatives are driven by patients' and employees' needs and expectations
58	Feedback received from patients, auditors and external parties are taken into consideration to improve processes
59	We routinely removes barriers to performance, innovation, and quality
60	There is an awareness of the wider healthcare industry performance, and a clear strategy is followed to benchmark performance with the top-class hospitals (at a domestic and national level).
61	There is no standard ambulance routes for picking and/or dropping patients
62	Standards/policies/procedures are regularly revised and audited
63	We have an effective process to report and respond to problems with IT, estates and equipment
64	The ED have made measurable improvements in response to patient feedback
65	We improve the standards related to patient care through audit and quality improvement techniques
66	We have a well-defined training program for employees to improve their personal and technical skills.
67	Nobody really seems to care whether quality requirements are met

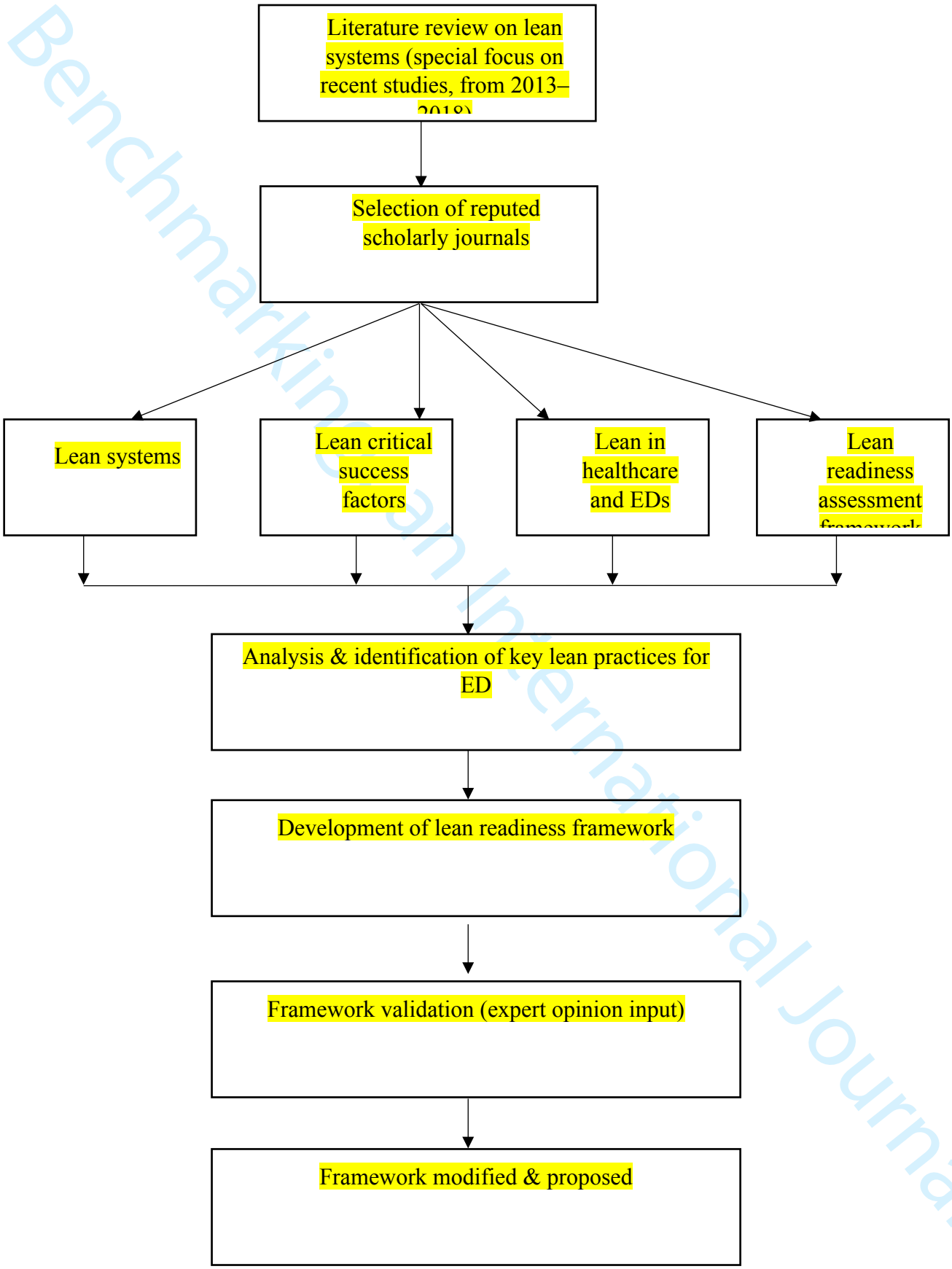


Figure 1 Flow chart of the research methodology

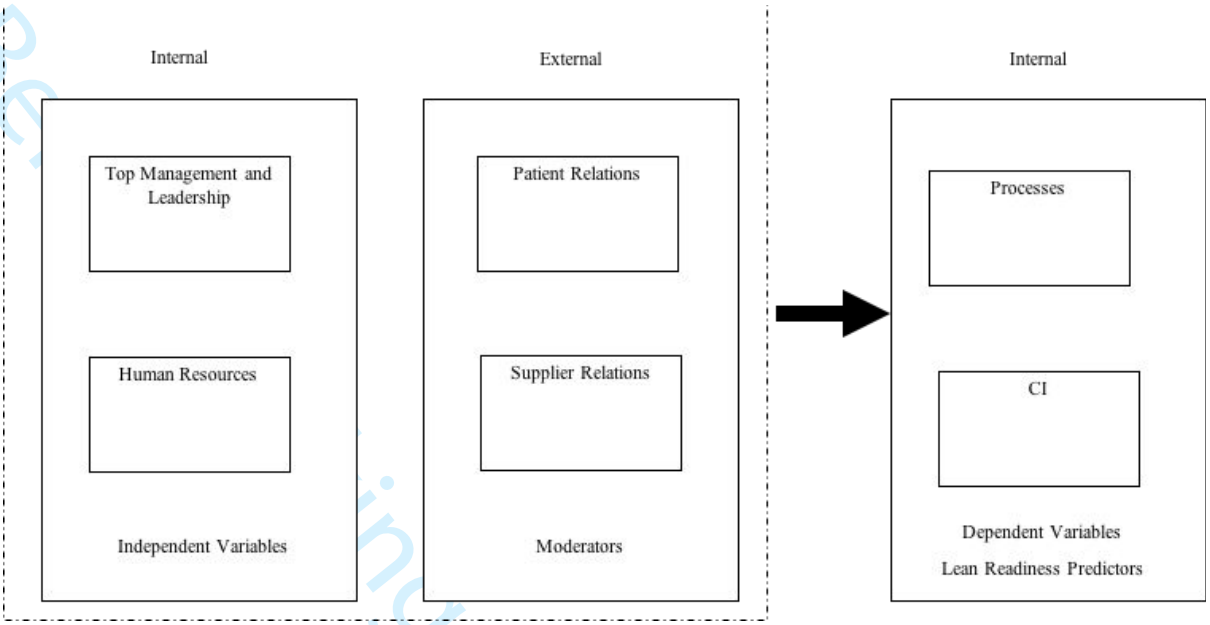


Figure 2 Figure 1: HLRA conceptual framework

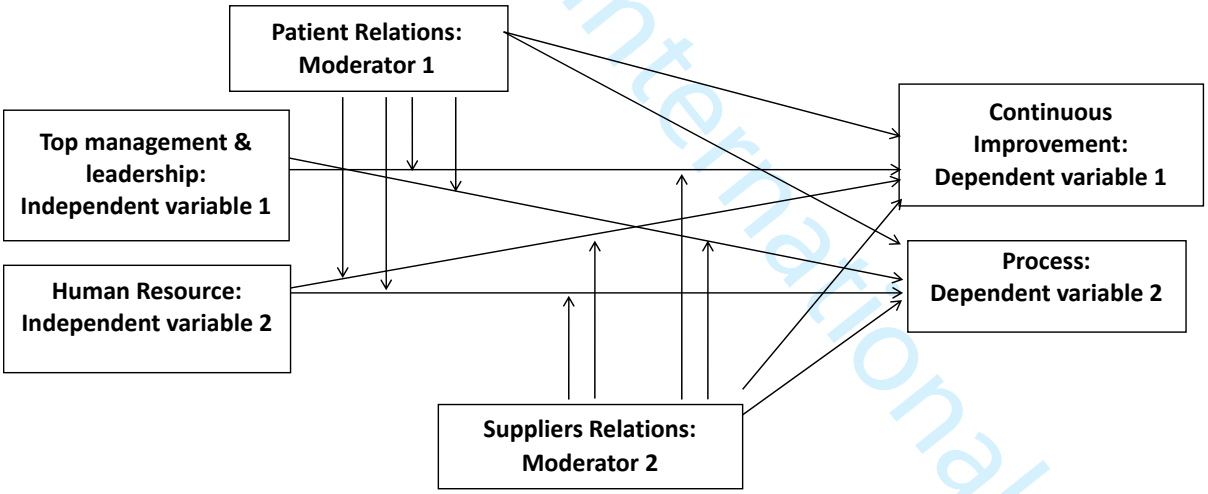
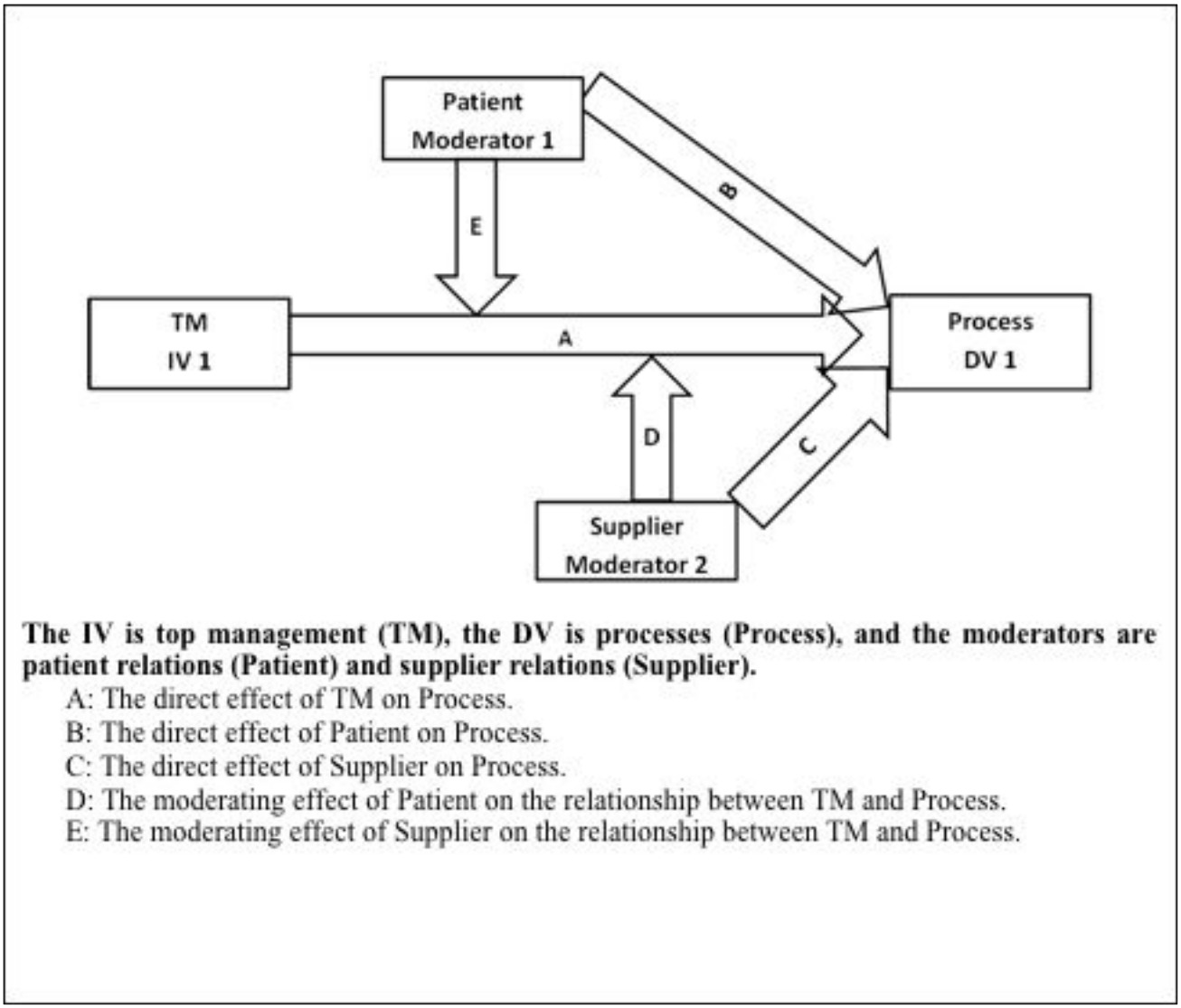


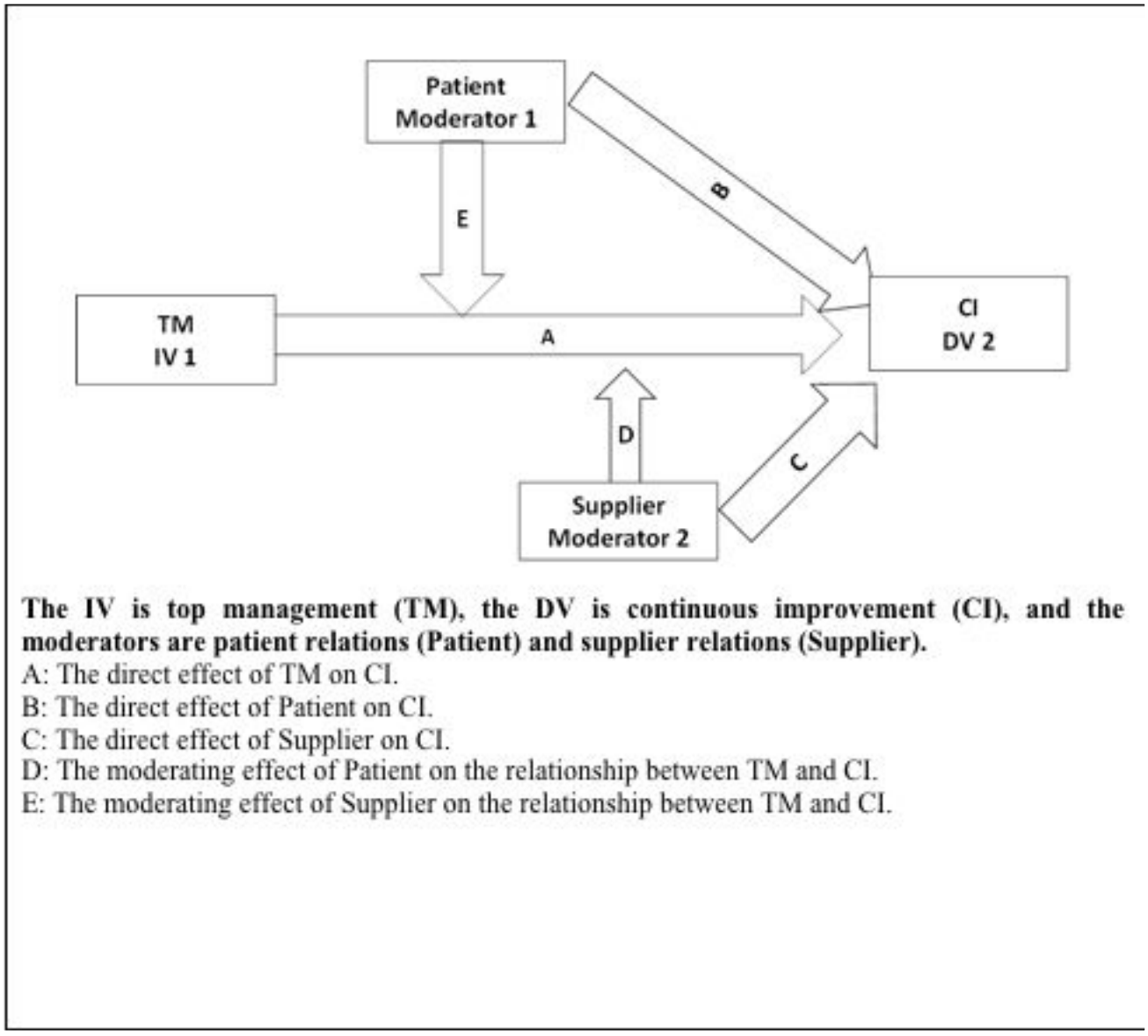
Figure 3: Relationships between the variables in the HLRA framework



The IV is top management (TM), the DV is processes (Process), and the moderators are patient relations (Patient) and supplier relations (Supplier).

A: The direct effect of TM on Process.
B: The direct effect of Patient on Process.
C: The direct effect of Supplier on Process.
D: The moderating effect of Patient on the relationship between TM and Process.
E: The moderating effect of Supplier on the relationship between TM and Process.

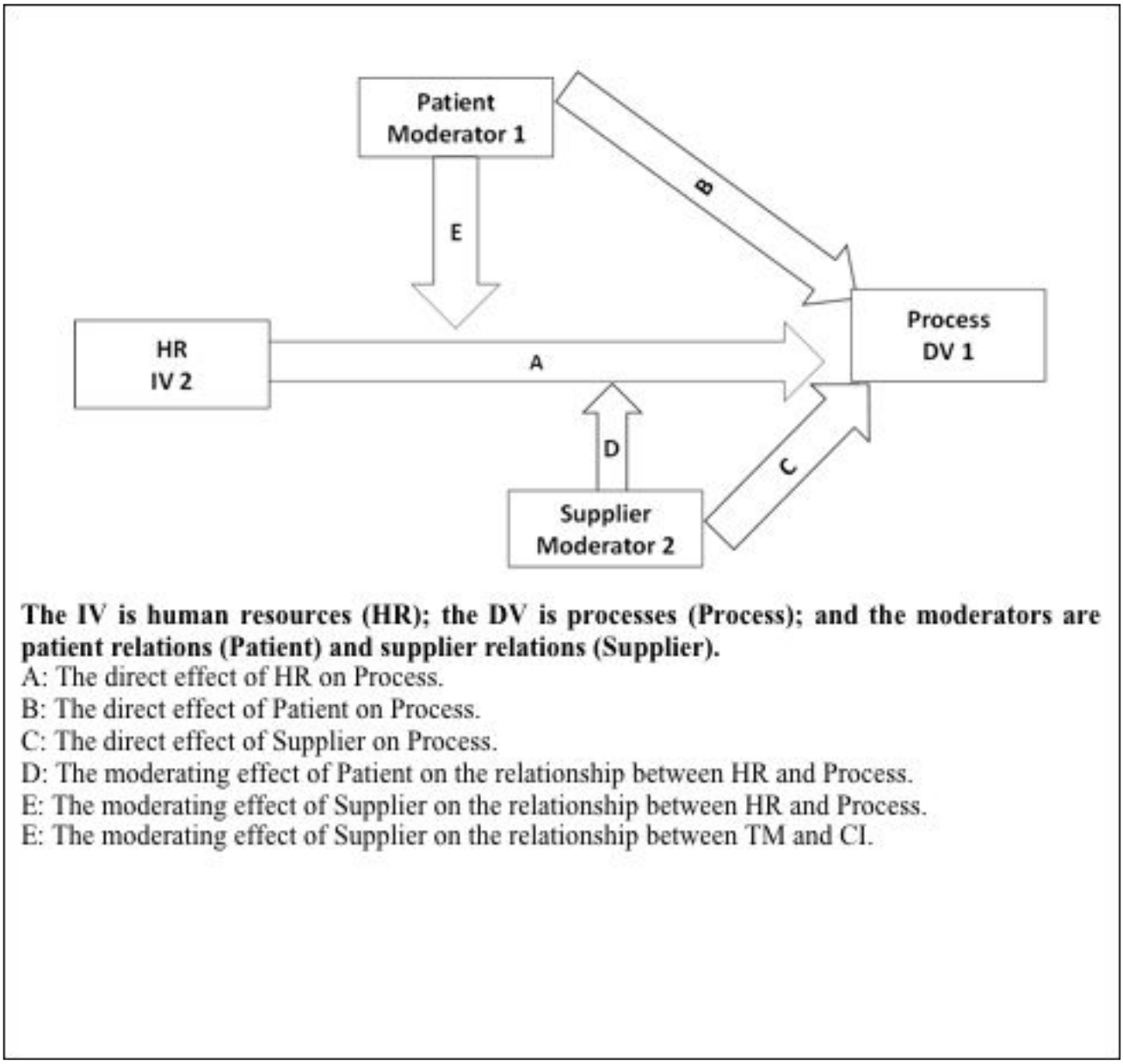
Figure 4 Model 1: The moderating effects of (i) patient relations and (ii) supplier relations on the effect of top management on processes



The IV is top management (TM), the DV is continuous improvement (CI), and the moderators are patient relations (Patient) and supplier relations (Supplier).

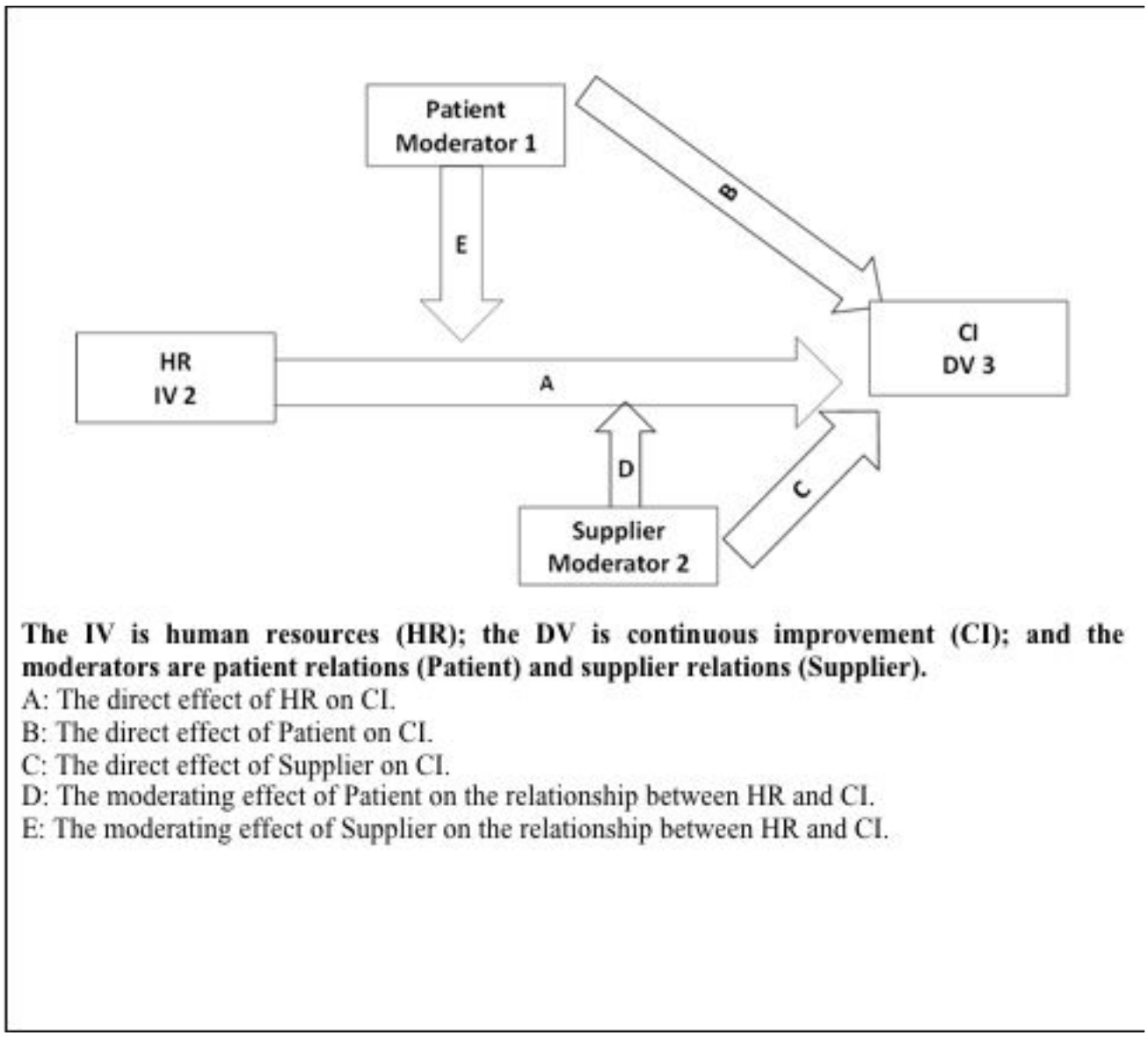
A: The direct effect of TM on CI.
B: The direct effect of Patient on CI.
C: The direct effect of Supplier on CI.
D: The moderating effect of Patient on the relationship between TM and CI.
E: The moderating effect of Supplier on the relationship between TM and CI.

Figure 5 Model 2: The moderating effects of (i) patient relations and (ii) supplier relations on the effect of top management on CI



The IV is human resources (HR); the DV is processes (Process); and the moderators are patient relations (Patient) and supplier relations (Supplier).
A: The direct effect of HR on Process.
B: The direct effect of Patient on Process.
C: The direct effect of Supplier on Process.
D: The moderating effect of Patient on the relationship between HR and Process.
E: The moderating effect of Supplier on the relationship between HR and Process.
E: The moderating effect of Supplier on the relationship between TM and CI.

Figure 6 Model 3: The moderating effects of (i) patient relations and (ii) supplier relations on the effect of human resources on processes



The IV is human resources (HR); the DV is continuous improvement (CI); and the moderators are patient relations (Patient) and supplier relations (Supplier).

A: The direct effect of HR on CI.
B: The direct effect of Patient on CI.
C: The direct effect of Supplier on CI.
D: The moderating effect of Patient on the relationship between HR and CI.
E: The moderating effect of Supplier on the relationship between HR and CI.

Figure 7 Model 4: The moderating effects of (i) patient relations and (ii) supplier relations on the effect of human resources on CI

Dear Editor and Reviewers,

First, I would like to thank you for taking the time to consider our paper and for providing us with valuable comments that I am sure will enhance the quality of our research. The following tables show how we have tried to address the comments and suggestions put forward.

Please note: The yellow highlighting in main paper indicates new additions by the authors. The red highlighting indicates words/phrases that were already there and is intended to guide the reviewers in relation to our responses to some of their queries.

1. **Originality: Does the paper contain new and significant information adequate to justify publication?:**

Reviewer	Comments	Action taken/comments by authors
RV1	Yes, the paper seems to be original with obvious knowledge gap.	Thank you for considering this paper original and as clearly identifying a gap in the literature.
RV2	No. This review paper is without any methodology and review work is also not substantial.	
RV3	Yes, it is a good paper and adds value to the field of knowledge on lean preparedness.	

2. Relationship to Literature: Does the paper demonstrate an adequate understanding of the relevant literature in the field and cite an appropriate range of literature sources? Is any signficant work ignored?:

Reviewer	Comments	Action taken/comments by authors
RV1	The literature review is fairly good, but no justification was found regarding how or based on what the readiness assessment framework was built upon. Also, the hypotheses development section should not include the number of questions used to measure the practice.	Thank you for making this point. The readiness assessment was based on essential factors that have been found in the literature and deemed to be essential for any emergency department (ED) to establish/sustain lean systems. This part can be seen in section 4 (highlighted in red), and in Tables 5–11. These tables break down each category as found in literature. In response to RV1's comment, details on the number of questions have been removed from the hypotheses development section. With regard to classical papers, we have tried to focus on the most recent, though less recent (2008-2018) and older studies have been included as well (please see section 2.3 and Table 4, highlighted in red). Example studies include: Baumol, W.
RV2	This paper demands a substantial literature review - rather than a counting of papers into some global categories to unearth gap for the field to advance its research in healthcare.	
RV3	All through the research papers from 2013-2018 are covered related earlier classical can be also included.	

		(1993) Hammer, M. and Champy, J. (1993) Laffel, G. and Blumenthal, D. (1989) Panizzolo, R. (1998) Tsang, J. and Antony, J. (2001) We have also updated the literature review (see table 4) by adding new classical references such as: Boyer, K. K. (1996), Karlsson, C. H., and Ahlström, P. (1996), and Sohal, A. S., and Egglestone, A. (1994),

3. Methodology: Is the paper's argument built on an appropriate base of theory, concepts, or other ideas? Has the research or equivalent intellectual work on which the paper is based been well designed? Are the methods employed appropriate?:

Reviewer	Comments	Action taken/comments by authors
RV1	No, the paper methodology section needs to be revisited. How you verified that the selected lean practices are the essential ones!! There is a clear mix up between literature, hypotheses development and methodology section.	We agree with the reviewers that the previous methodology was not clear enough. The methodology section has been revisited and rewritten in section 3 (highlighted in yellow). As per one of the reviewer's suggestions, we contacted some experts in lean healthcare to validate our proposed framework; this is detailed in section 3, highlighted in yellow.
RV2	This section is totally absent.	
RV3	A methodology based on data set collected from respondents would have added value to theory building.	

4. Results: Are results presented clearly and analysed appropriately? Do the conclusions adequately tie together the other elements of the paper?:

Reviewer	Comments	Action taken/comments by authors
RV1	The results need to be clarified	Again, we feel that the reviewers' points here are valid. We have revisited this section and now specify where the findings can be found. Section 4 (and specifically 4.7) presents the findings, which include the development of a conceptual framework to assess lean readiness within ED (highlighted in red). This enables us to answer the main research questions: 1. What are the prerequisites that EDs have to satisfy to be ready for lean implementation?
RV2	No such section is seen.	
RV3	found inadequate and can be extended further.	

		2. How can lean readiness within EDs be assessed?

5. Implications for research, practice and/or society: Does the paper identify clearly any implications for research, practice and/or society? Does the paper bridge the gap between theory and practice? How can the research be used in practice (economic and commercial impact), in teaching, to influence public policy, in research (contributing to the body of knowledge)? What is the impact upon society (influencing public attitudes, affecting quality of life)? Are these implications consistent with the findings and conclusions of the paper?:

Reviewer	Comments	Action taken/comments by authors
RV1	There is a need for deeper discussion for the implications of lean on emergency departments	The implications section has been incorporated into the discussion and conclusion section; in addition, further explanations have been added (highlighted in yellow; please see section 5).
RV2	Not provided in explicit section. In addition, implications have been not clearly spelled out.	
RV3	Implications for research, practice and/or society needs to be more clearly established.	

6. Quality of Communication: Does the paper clearly express its case, measured against the technical language of the field and the expected knowledge of the journal's readership? Has attention been paid to the clarity of expression and readability, such as sentence structure, jargon use, acronyms, etc.:

Reviewer	Comments	Action taken/comments by authors
RV1	The quality of communication is fair, but it should be proofread. Also consider checking the journal format, tables and citations.	The article has been sent to a professional proofreader to ensure readability, grammatical accuracy, and adherence to the journal's guidelines in terms of referencing and tables.
RV2	This requires considerable improvement.	
RV3	Communication is good.	

References:

Baumol, W. (1993), "Health care, education and the cost disease: a looming crisis for public choice", *Public Choice*, Vol. 77, pp. 17–28.

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Laffel, G. and Blumenthal, D. (1989), "The case for using industrial quality management science in health care organizations", *JAMA*, Vol. 262, No. 20, pp. 2869–2873.

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Tsang, J. and Antony, J. (2001), "Total quality management in UK service organizations: some key findings from a survey", *Managing Service Quality,* Vol. 11 No. 2, pp. 132–141.